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ABSTRACT

This document contains the following full and short papers from ICCE/ICCAI 2000 (International Conference on Computers in Education/International Conference on Computer-Assisted Instruction): (1) "A Code Restructuring Tool To Help Scaffold Novice Programmers" (Stuart Garner); (2) "An Assessment Framework for Information Technology Integrated Instruction" (Chuan-Shih Wang and Chia-Chin Li); (3) "An Authoring Shell with Intelligent Reuse" (Kam W. Li, Jill Slay, and Warren James); (4) "An Educational Application of Integrated Route Information Service on the Internet" (Tun-Wen Pai, Chao-Lin Liu, and Chih-Yao Yang); (5) "Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming" (Jun Moriyama); (6) "Design and Implementation of a N-Tiered Heterogeneous Virtual School Administration System" (Huang Gooshyon); (7) "Design and Implementation of a WWW-Based School Official Memorandum System" (Gi-Ping Lee, Yue-Shan Chang, Ching-Chuan Chou); (8) "DIYexamer: A Web-Based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment" (Ying-Dar Lin, Wen-Chun Sun, Chien Chou, Huan-Yun Wei); (9) "Empowering Secondary School Teachers To Effectively Exploit Internet Resources for the Enhancement of Teaching and Learning" (Y. T. Yu and B. C. Chiu); (10) "Examining Problems of Student Teachers To Build a Web-Supported Environment" (Shihkuan Hsu and Hsiou-Huai Wang); (11) "Implementing Modern Approaches to Teaching Computer Science: A Cross-Cultural Perspective" (Jill Slay and Kam W. Li); (12) "Initial Evidence for Representational Guidance of Learning Discourse" (Daniel D. Suthers); (13) "Learning from the Learning of Other Students" (Stuart Garner); (14) "Localization of a Feature Extraction Area for Touch-Type Training Using a Camera" (Masayuki Arai, Hiroyoshi Watanabe, Kenji Oguri, and Shigeo Takei); (15) "Present State and Future Direction of Woman Informatization Education in Korea" (In-Hwan Yoo, Chul-Hyun Lee, Soo-Bum Shin, and Tae-Wuk Lee); (16) "Reflections on Educational Technology from Female Asian Faculty's (FAF) Perspectives" (Doris Lee, Amy S. C. Leh, Mei-Yan Lu, and Mei-Yau Shih); (17) "Space Plan for Effective Educational Software Utilization in Korea" (Soo-Bum Shin, Chul-Hyun Lee, In-Hwan Yoo, and Tae-Wuk Lee); (18) "The Web of the Teacher Professional Development" (Chia-Ling Hsu, Hsiao-Ching She, and

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Min-Sheng Lin); and (19) "Using Learning Object Meta-Data in a Database of Primary and Secondary School Resources" (Daniel D. Suthers). (MES)

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Proceedings

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A Code Restructuring Tool to help Scaffold Novice Programmers

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This paper concerns a new software tool called CORT (code restructuring tool) that has been developed by the author to help students learn programming. The paper begins by discussing the difficulties that students face when learning to program and the use of part complete solutions as a teaching and learning method that reduces the cognitive load that students experience.

CORT has been developed to support this use of part complete solutions and its features are outlined. When used by a student, a part complete solution to a given programming problem is displayed in one window and possible lines of code that can be used to complete the solution are displayed within another window. The lines can easily be moved between the windows in order to complete the solution and the solution then transferred to the target programming environment for testing purposes.

Finally, the use of CORT with both undergraduate and postgraduate students at Edith Cowan University is described, preliminary feedback from students indicating that CORT is easy to use and that they perceive that it is helping them in their learning of programming. Four different methods of using CORT have been identified and these will be the subject of future research.

Keywords: **Scaffolding, Programming, Flexible Learning.**

1 Introduction

Learning to write computer programs is not easy [3, 18] and this is reflected in the low levels of achievement experienced by many students in first programming courses. For example, Perkins, Schwartz et al [17] state that:

> *Students with a semester or more of instruction often display remarkable naivete about the language that they have been studying and often prove unable to manage dismayingly simple programming problems.*

and King, Feltham et al [8] state that:

> *even after two years of study, many students had only a rudimentary understanding of programming*

Over the years since the advent of high level programming languages in the 1960s, much has been written about the problems that students have in learning programming and many ideas and initiatives have been put forward for improvements in the teaching and learning process with varying degrees of success. In practice, the ways in which teaching and learning takes place in the domain of programming have changed little and many students still find the learning of programming a very difficult process. The challenge of learning programming in introductory courses lies in simultaneously learning: general problem solving skills; algorithm design; program

design; a programming language in which to implement algorithms as programs; and an environment to support the program design and implementation [6]. In addition, students need to learn testing and debugging techniques to validate programs and to identify and fix problems that they may have within their programs.

Additionally, we are moving ever more rapidly to use more student centred and flexible learning methods within the teaching and learning process. This means that our instructional design for programming courses needs to take notice of these moves and utilise these methods. Fortunately technological improvements have also been significant over the last few years enabling us to more easily produce engaging courseware that can help students studying in a flexible learning mode. As courseware designers, we can produce electronic scaffolds to help students in their learning processes when they are studying on their own with limited access to a human tutor.

2 Use of Worked Examples in the Teaching and Learning of Problem Solving and Programming

There are several methods used in the teaching and learning of programming and one of these is to utilise worked examples. Several researchers have experimented with the use of worked examples in place of conventional instruction and found strong advantages. In the domain of algebra, Sweller and Cooper [19] suggested that students would learn better by studying worked examples until they had "mastered" them rather than attempting to solve problems as soon as they had been presented with, or familiarised themselves, with new material. In their research, students studied worked examples and teachers answered any questions that the students had. Students then had to explain the goal of each problem together with the steps involved in the solution and then complete similar problems until they could be solved without errors. Sweller and Cooper found that this method was less time-consuming than the conventional practice-based model and that students made fewer errors in solving similar problems than students who were exposed to the conventional practice-based model of instruction. There was no significant difference between the "worked example" group and the "conventional" problem solving group when they attempted to solve novel problems and it was therefore concluded that learning was more efficient and yet no less effective when this worked example method was used.

Worked examples are heavily used within the "reading" method of learning programming. According to Van Merrienboer et al [22, 23] the reading approach emphasises the reading, comprehension, modification and amplification of non-trivial, well-designed working programs. However, they also suggest that presenting worked examples to students is not sufficient as the students may not "abstract" the programming plans from them, a plan being a stereotyped sequence of computer instructions as shown in figure 1.

"Mindful" abstraction of plans is required by the voluntary investment of effort and the question then arises as to how we can get students to study the worked examples properly. In practice, students tend to rush through the examples, even if they have been asked to trace them in a debugger, as they often believe that they are only making progress in their learning when they are attempting to solve problems.

Lieberman [10] suggests that students should annotate worked examples with information about what they do or what they illustrate. Another suggestion is to use incomplete, well-structured and understandable program examples that require students to generate the missing code or "complete" the examples. This latter approach forces students to study the incomplete examples as it would not be possible for their completion without a thorough understanding of the examples' workings. An important aspect is that the incomplete examples are carefully designed as they have to contain enough "clues" in the code to guide the students in their completion. It is suggested that this method facilitates both automation, students having blueprints available for mapping to new problem situations, and schemata acquisition as they are forced to mindfully abstract these from the incomplete programs [24].

In one study, two groups of 28 and 29 high-school students from grades 10 to 12 participated in a ten lesson programming course using a subset of COMAL-80 [24]. One group, the "generation" group, followed a conventional approach to the learning of programming that emphasised the design and coding of new programs. The other group, the "completion" group, followed an approach that emphasised the modification and extension of existing programs. It was found that the completion group was better than the generation group in constructing new programs. It was found that the percentage of correctly coded lines was greater and that looping structures were more often combined with correct variable initialisation before a loop together with the correct use of counters and accumulators within the loop. It would appear that the completion strategy had indeed resulted in superior schemata formation for those students within that group. In addition, the completion group used superior comments in connection with the scope and goals of the programs, indicating that they had developed better high-level templates or schemata. It was noted in the study however that both groups were

equal in their ability to interpret programs and that this might indicate that students in the completion group do not understand their acquired templates. It is then suggested that future completion strategies should include the annotation of the examples by students with details of what they are supposed to do and details of the templates (plans) that are being used.

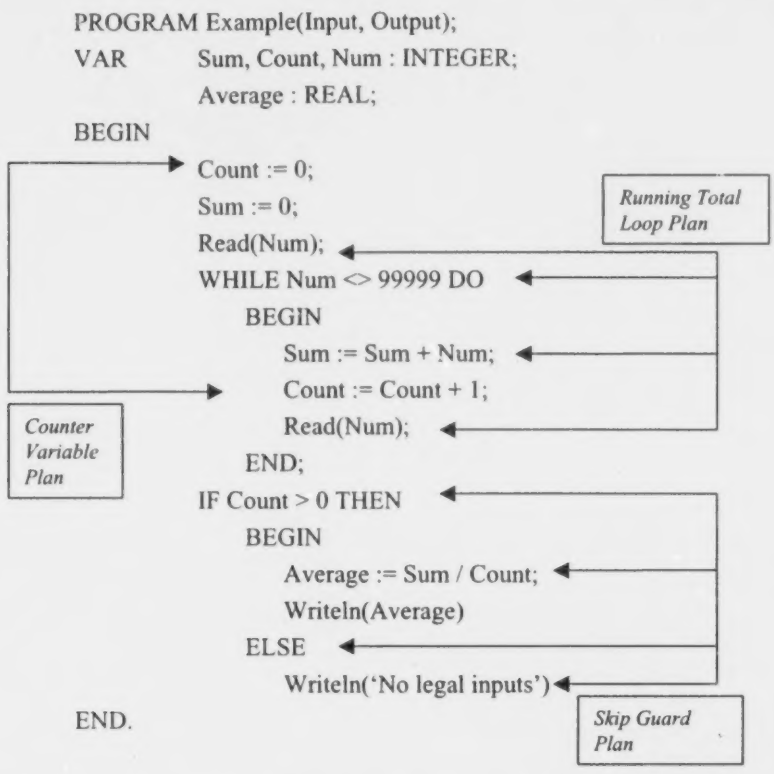

Figure 1

A side effect of the research was also noted. The drop-out rate from the completion group was found to be lower than for the generation group, particularly for female students with low prior knowledge. It was suggested that perhaps the generation of complete programs is perceived as a difficult and menacing task and that the completion strategy overcomes this difficulty.

The stimulation of the "mindful of abstraction" of schemata in students can possibly be improved further requiring them to also annotate the solutions with details of the scope and goals of the solutions and to answer questions on the inner workings of the solutions. The "degree" of completion of the solutions is an important aspect within the completion strategy and in some later work [23] examples are given of completion assignments that might be used early and later in a programming course. In an early part of a course, an example may indeed be complete and include explanations and a question on its inner workings. In the latter part of a course, the example may be largely incomplete and include a question on its workings and an instructional task. Between these two extremes, examples will have varying degree of completeness and in all cases, the incomplete examples are acting as scaffolds for the students.

3 The Cloze Procedure

A scaffolding tool called CORT (Code Restructuring Tool) has been produced that allows students to fill in lines of missing code from programs and this method is based upon the cloze procedure. The term is derived from "closure", a Gestalt psychology term referring to the human tendency to complete a familiar but not quite

finished pattern [2]. The use of cloze was first used to measure comprehension in English readability [9] however it has also been used in the teaching and learning of programming as a way of measuring student understanding of programs [7, 20]. Such program comprehension tests are constructed by replacing some of the "words" or tokens by blanks and requiring students to fill in the blanks during a test. The use of the cloze procedure in testing was found to correlate well with conventional comprehension, question – answer, type quizzes and is also much easier to create and administer, see for example the work of Cook, Bregar et al [2].

Other researchers have experimented with the testing of program comprehension by omitting complete lines of code from programs and requiring students to fill in those lines [5, 13. 14, 15, 16]. Norcio found that students were more likely to supply correct statements if they had been omitted within a logic segment rather than from the beginning of a segment. This is consistent with the chunking hypothesis [12] that specifies that the first element of a chunk provides the key to the contents of the entire unit. Ehrlich looked at the differences between experts and novices in filling in missing lines within various programming plans and, as expected, found that the experts filled in the lines correctly taking into account the surrounding plan whereas novices had more difficulty.

In the various experiments in program comprehension using the cloze procedure, the students had to fill in the lines of code without being given a selection of lines to choose from. In some work done in an area unrelated to programming, students were expected to create an essay using a file of statements, only some of which were relevant to the topic [4]. The students were expected to copy and paste only the statements which they believed to be relevant and then to link them with their own text and it was suggested that learners would consolidate their understanding of the topics by having to actively evaluate all possible statements. The file of statements was acting as a scaffold to student learning.

Although the literature suggests that the cloze procedure has only been used in measuring program comprehension, it appears that it could prove useful as a way of scaffolding student learning of programming. An incomplete solution to a programming problem could be given to a student together with a choice of statements that might be used in the solution. The student would then have to study the incomplete solution and the choice of statements and decide which statements to use and where to put them. CORT uses this idea making the mechanics of placing the statements into the incomplete solution very straightforward for the student and eliminating typing errors and therefore also syntax errors.

4 The Code Restructuring Tool (CORT)

CORT has been designed to support the "completion" method of learning to program and it was decided that the following features would be required in the first prototype:

- Support for part-complete solutions to programming problems. Such solutions help in schemata creation and also reduce cognitive load.
- A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution. This provides scaffolding for students.
- A facility so that students can add and amend lines of code. This would allow scaffolding to be reduced and for students to add more of their own code.
- For visual programming, a facility for students to easily view the target interface. The interface should be annotated with the various object names thereby reducing any split-attention effect and helping reduce cognitive load [1].
- A facility to access tutor created questions concerning the programming problems being attempted and for students to enter answers to those questions. This will promote reflection and higher order thinking.
- A facility to easily transfer a completed solution from CORT to the target programming environment.
- A facility to easily transfer programming code from the target programming environment back into CORT for further amendment.

4.1 The CORT Design

The user interface of CORT has been designed taking into consideration the three issues that have been suggested by Marcus [11] as being fundamental to interface design, namely development, usability, and acceptance. The interface for CORT is shown in figure 2.

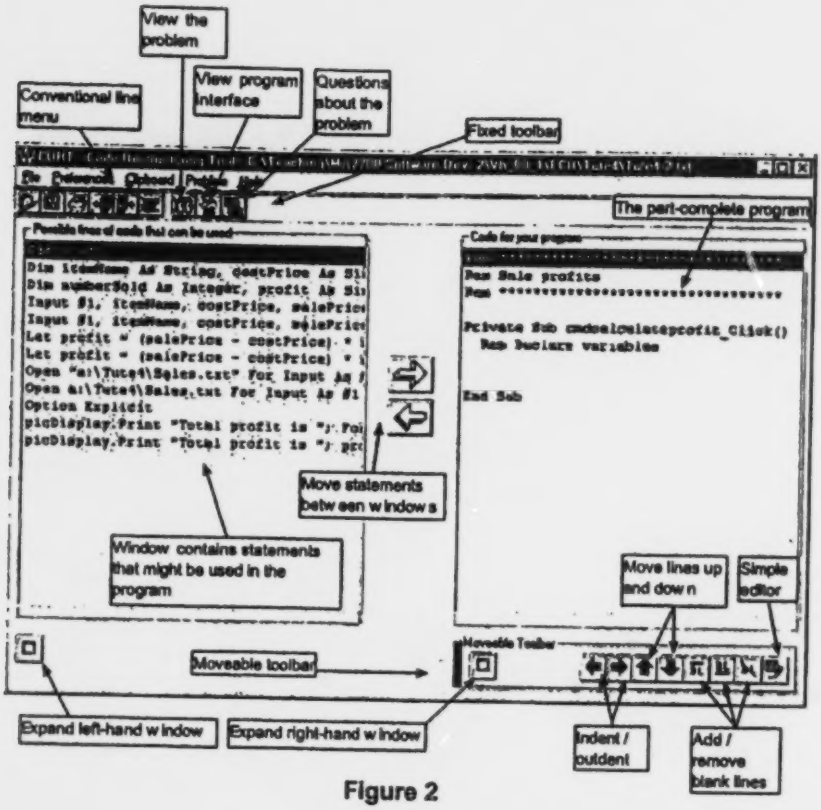

Figure 2

The ways in which the CORT design supports the list of required features are described in the following table.

Feature	Support in CORT Design
Support for part-complete solutions to programming problems	The part-complete solutions are automatically loaded into the right hand window and possible statements into the left hand window. Students load these from a file.
A mechanism so that missing statements can easily be inserted into a part-complete solution and also moved within that solution	Two buttons in the middle of the screen will move lines between the windows. One line, or several lines can be selected and moved across.
A facility so that students can add and amend lines of code	A simple editor is provided so that students can add their own lines or amend existing lines.
For visual programming, a facility for students to easily view the target interface	Access to this feature is via a button on the fixed toolbar.
A facility to access tutor created questions on the workings of the programming examples and to enter student answers	Access to this feature is via a button on the fixed toolbar. Student answers are automatically saved.
A facility to easily transfer a completed solution from CORT to the target programming environment	This is provided by a button on the main toolbar. A single click will copy the contents of the right hand window to the Windows clipboard ready for pasting into the Visual BASIC programming environment.

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A facility to easily transfer programming code from the target programming environment back into CORT for further amendment	This is provided by a button on the main toolbar. A single click will paste the contents of the Windows clipboard into the right hand window, overwriting what is there.

4.2 Use of CORT by Students

A student would typically use CORT as follows:

1. A student loads in a CORT file and the two windows display a part-complete solution to a problem together with possible lines to be used. There is a facility available for the contents of the two windows to be printed out.
2. The student can view the problem statement and the Visual BASIC solution interface by clicking on the appropriate buttons on the fixed toolbar. The problem statement may have already been provided to the student in the form of a handout, however there is also a facility to print it from within CORT.
3. The student moves certain lines from the left hand window to the right hand window in an attempt to complete the solution. Lines can be moved up or down, and indented or outdented in the right hand window. Some problems have too many lines in the left hand window, some of those lines being incorrect.
4. If necessary, the student can invoke a simple editor to amend, add or delete lines of code.
5. The student clicks on the appropriate button to copy the contents of the right hand window to the Windows clipboard.
6. The student invokes Visual BASIC and loads the file that contains the interface for the solution. This is in effect the Visual BASIC solution to the problem without the lines of code and was created by the tutor.
7. The student pastes the contents of the Windows Clipboard into the Visual BASIC editor and tests the program to determine if it works correctly. Use is made of the trace and debugging facilities of Visual BASIC. These facilities provide an insight to the workings of the notional machine.
8. If the student finds a problem with the working of the program, they can return to CORT and make the changes to the code there.
9. The student repeats steps 3 to 8 until they have a working program.
10. The student answers the tutor's questions concerning the programming problem that they have just attempted.

4.3 Initial Student Feedback

CORT has been used for one semester with both undergraduate and postgraduate students in the Faculty of Business and Public Management. The particular units are in the area of software development and the language that the students learn is Visual BASIC.

Each week the students have to undertake completion programming exercises using CORT and after each problem they were asked to comment on the use of CORT for the particular problem that they had just finished. The data was collected on-line through the Web and below are some of the comments that were received:

1. It's very helpful. I can see the interface of the program before actually running it.
2. I think CORT is a very useful tool to play around the codes. It saves me time copying and pasting.
3. Considering the increased workload as the semester progresses it is a bit of a relief that the exercises are much easier with the "fill in the gap" type format in CORT.
4. Without CORT, it's sure that I'll have a lot trouble with this particular problem, which focuses on arrays (a difficult topic). Thanks CORT...
5. CORT was useful in that the part solution helped to understand the logic of VB code
6. CORT is useful . However, I have used the unit text to try to understand the indentation format when writing the code. The directional keys are great for editing the code to meet the required format.

7. This was a challenge! I think that CORT is useful so long as I am not tempted to simply manipulate code until the program runs. If I were having to write programs from scratch I would use CORT so as to format and manipulate code and modules or sub procedures etc.

5 Conclusions

As can be seen from the above, the initial feedback on the use of CORT has been favourable. We have found that students can undertake two or three small programming problems within a one hour tutorial whereas without CORT they could only undertake one such problem. Also, without using CORT students often never manage to successfully complete their assigned problems and this certainly affected their motivation.

By using CORT, students do not have to be concerned with the design of programming interfaces which considerably reduces the cognitive load in the initial stages of learning programming. Also, the reduction of "split attention affect" by labelling all the objects with their names has been very popular with the students.

The above has described a preliminary study of the use of CORT and it has been undertaken to determine its suitability and to fine tune some of its features. CORT can be used in several ways and four distinct methods have now been identified. These will be the subject of further research. The four methods are as follows:

1. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are no extra lines displayed in the left hand window.
2. **All** of the lines that are required to complete a program are made available in the left hand window of CORT. There are also additional lines displayed in the left hand window that are not required within the program. The extra lines are similar to the required lines, however they are incorrect and act as "red herrings".
3. **Some** of the lines that are required to complete a program are made available in the left hand window of CORT. Other lines that are required for the program completion need to be keyed in by the student.
4. **None** of the lines that are required to complete a program are made available in the left hand window of CORT. All of the lines that are required for the program completion need to be keyed in by the student.

References

[1] Chandler, P. and Sweller, J. (1991). Cognitive load theory and the format of instruction. Cognition and Instruction 8: 293-332.

[2] Cook, C., Bregar, W., et al. (1984). A Preliminary Investigation of the use of the Cloze Procedure as a Measure of program Understanding. Information Processing & Management **20**(1-2): 199-208.

[3] du Boulay, B. (1986). Some Difficulties in Learning to Program. Journal of Educational Computing Research **2**(1): 57-73.

[4] Edward, N. (1997). Development of a cost effective computer assisted learning (CAL) package to facilitate conceptual understanding. CAL97, University of Exeter, UK.

[5] Ehrlich, K. and Soloway, E. (1984). An Empirical Investigation of the Tacit Plan Knowledge in Programming. Human Factors in Compter Systems. J. Thomas and M. L. Schneider. Norwood, New Jersey, Ablex: 113-133.

[6] Fowler, W. A. L. and Fowler, R. H. (1993). A Hypertext Approach to Computer Science Education Unifying programming Principles. Journal of Multimedia and Hypermedia **2**(4): 433-441.

[7] Hall, W. E., III and Zweben, S. H. (1986). The Cloze Procedure and Software Comprehensibility Measurement. IEEE Transactions on Software Engineering **May 1986**: 608-623.

[8] King, J., Feltham, J., et al. (1994). Novice Programming in High Schools: Teacher Perceptions and New Directions. Australian Educational Computing(Sep 1994,): 17-23.

[9] Klare, G. R. (1974-75). Assessing Readability. Reading research quarterly(10): 63-102.

[10] Lieberman, H. (1986). An Example Based Environment for beginning Programmers. Instructional Science **14**(3): 277-292.

[11] Marcus, A. (1992). Graphic Design for Electronic Documents and User Interfaces. New York, ACM Press.

[12] Miller, G. A. (1956). The Magical Number Seven, Plus or Minus Two: Some Limits on our Capacity to Process Information. Psychological Review(63): 81-97.

[13] Norcio, A. F. (1980a). Comprehension Aids for Computer Programs. American Psychological Association Annual Meeting, Montreal.

[14] Norcio, A. F. (1980b). Human Memory Processes for Comprehending Computer Programs. Cybernetics and Society, Cambridge, Massachusetts.

[15] Norcio, A. F. (1981). Chunking and Understanding Computer Programs. Human-Machine Systems Symposium, Boston, USA.

[16] Norcio, A. F. (1982). Indentation, Documentation and Programmer Comprehension. Human Factors in Computer Systems, Gaithersburg, Maryland.

[17] Perkins, D. N., Schwartz, S., et al. (1988). Instructional Strategies for the Problems of Novice Programmers. Teaching and Learning Computer Programming: Multiple Research Perspective. R. E. Mayer, Hillsdale, NJ: Erlbaum: 153-178.

[18] Scholtz, J. and Wiedenbeck, S. (1992). The role of planning in learning a new programming language. International journal of man-machine studies **37**: 191-214.

[19] Sweller, J. and Cooper, G. A. (1985). The use of worked examples as a substitute for problem solving in learning algebra. Cognition and Instruction **2**(1): 59-89.

[20] Thomas, M. and Zweben, S. (1986). The Effects of Program-Dependent and Program-Independent Deletions on Software Cloze Tests. Empirical Studies of Programmers: 138-152.

[21] van Merrienboer, J. J. G. (1990). Strategies for Programming Instruction in High School: Program Completion vs. Program Generation. Journal of educational computing research. **6**(3): 265-.

[22] van Merrienboer, J. J. G. and Krammer, H. (1987). Instructional Strategies and tactics for the design of Introductory Computer programming Courses in High School. Instructional Science **16**(3): 251-285.

[23] van Merrienboer, J. J. G., Krammer, H. P. M., et al. (1994). Automating the planning and construction of programming assignments for teaching introductory computer programming. Automating Instructional Design, Development, and Delivery (NATO ASI Series F, Vol. 119). R. D. Tennyson, Springer Verlag, Berlin.: 61-77.

[24] van Merrienboer, J. J. G. and Paas, F. (1990). Automation and Schema Acquisition in learning elementary computer programming. Computers in Human Behavior(6): 273-289.

An Assessment Framework for Information Technology Integrated Instruction

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Information technology integrated instruction is the education tendency in the future, and it is also an important issue in the development of education in Taiwan. An assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference. This article proposes an framework for assessing information technology integrated instruction. The framework includes kernel and periphery parts. Kernel part refers to the whole teaching process, including information technology, curricula, learning materials, instructional strategies, learning activities, and evaluation. Periphery part refers to the surroundings situation, including teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

Keywords: **information technology integrated instruction, technology integration, educational technology, evaluation**

1 Introduction

The rapid development of information technology (IT) has not only brought about major effect on economy and industry but also made a great impact on society and education. In particular, the prevalent use of computers and the rapid development of the Internet have gradually changed our life style and pattern, with their impact on education being unprecedented. Many educators and policy makers believe that technology can be a catalyst for educational reform [3,4,10]. They suggest that the use of technology in classrooms will shift the roles of teachers and students. Teachers will act more like facilitators by helping students access information, process it, and communicate their understanding [4].

Beginning the 2001 academic year, Taiwan will implement phase-by-phase the nine-year integrated curriculum for its elementary and junior high schools [11]. To cultivate students' basic ability to "apply technology and information", the new curriculum will have to emphasize integrating IT into the teaching of various courses. Amid this major reform of curriculum, the Computer Center of the Ministry of Education has planned for the integration of information curriculum with other areas of learning [7]. At the same time, it has selected 18 elementary and junior high schools in which teaching experimentations will be carried out [1]. Therefore, an assessment framework is needed during experimenting with integrated instruction and when integrated instruction is officially implemented. The framework can help us understand the implementation and provide information for future reference.

2 The essence of information technology integrated instruction

The United States has implemented IT integrated instruction for years. Many educators are now actively using technology along with effective teaching strategies to integrate technology into their curriculum [9]. In contrast, IT integrated instruction is still a newly heard noun in Taiwan. Many teachers are unfamiliar with it, and some think of it as another name for computer-assisted instruction (CAI). Information technology has

developed rapidly, and the role of IT in education has changed over these years, from being an auxiliary to teaching to being an indispensable tool of education. Therefore, IT integrated instruction is distinguished from CAI.

In IT integrated instruction, information technology is an indispensable tool in the teaching environment because it is integrated into the curriculum, learning materials, teaching and learning [2]. Moreover, the traditional curriculum, materials, and teaching are transformed through the characteristics of information technology: the subject-based curriculum and materials become student-based; the teacher-driven teaching activities become student-centered. Information technology is integrated when it is used in a seamless manner to support and extend curriculum objectives and to engage students in meaningful learning. It is not something one does separately; it is part of the daily activities taking place in the classroom [3].

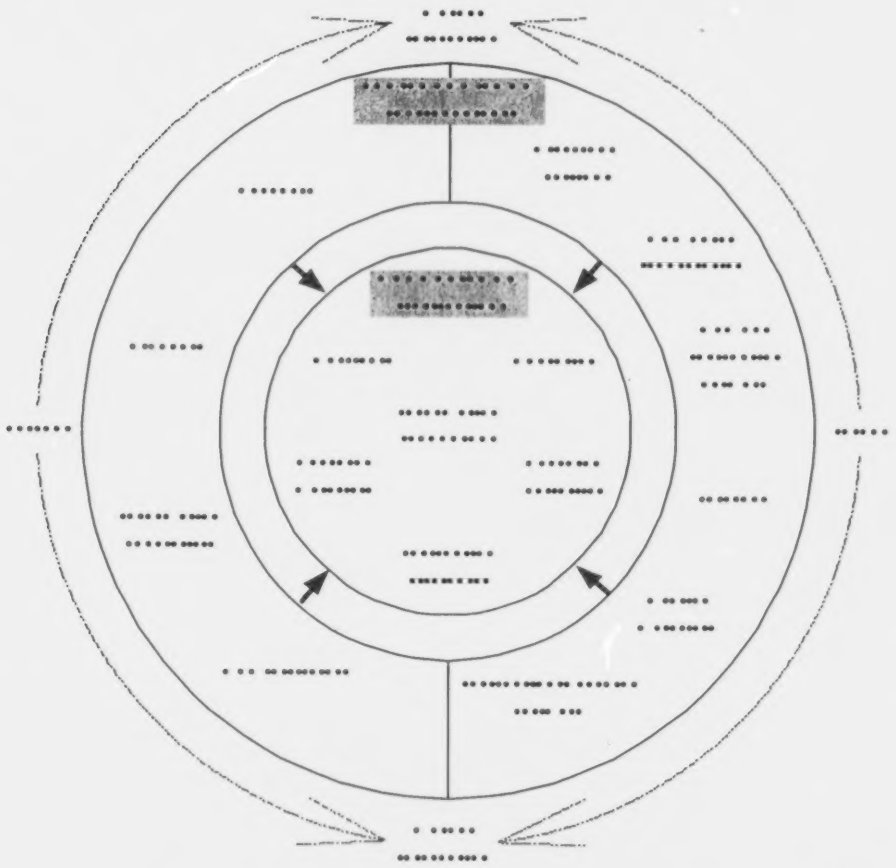

Figure 1. The assessment framework for information technology integrated instruction

Figure 1 depicts the assessment framework of IT integrated instruction. The assessment framework consists of two major parts: Kernel Part and Periphery Part. The kernel part primarily assesses the whole teaching process. Because the implementation of IT integrated instruction will bring about changes to teaching, the aspects to be assessed in this part should include not only the use of IT in teaching but also other perspectives of teaching: curricula, learning materials, instruction strategies, learning activities, and evaluation. The periphery part primarily assesses the teaching environment, learning resources, information equipment, personnel qualities, and administrative as well as professional support. All these factors will influence the outcome of teaching. In particular, IT integrated instruction is in need of supportive and coordinated environmental conditions. There are many perspectives of the periphery part that are related

with IT integrated instruction, and ten of them are carefully identified and included for assessment: teachers, students, information specialists, administrators, classroom settings, computer laboratories, campus instruction network, Internet, digital materials, and instruction/learning software.

3 Assessing the kernel part

The kernel part refers to the whole teaching process, and Table 1 shows the perspectives and emphases to be assessed. The aspects of the kernel part are illustrated in the following paragraph.

Table 1. Emphases of the kernel part to be assessed

Perspective	Emphasis
Information technology	The use and role in instruction
Curricula	Subject-based separate curricula or Student-centered integrated curricula
Learning materials	Sequential or problem-based
Instructional strategies	Traditional expository approach or constructivist approach
Learning activities	Teacher-driven or student-centered
Evaluation	Traditional paper-and-pencil testing or multiple assessment

3.1 Information Technology

Information technology may refer to equipment or products, such as computers, network, peripherals, etc. It may also refer to the methods or processes in which the equipment of IT is used to help with the solution of problems. It is the purpose of implementing IT integrated instruction not only to enable students to use the equipment or products of IT but also to use the IT equipment to solve practical problems in learning and life.

In this perspective, we care about how IT is used in teaching and what role IT plays in teaching. The level of the use and role in instruction is developed:

- Nil (level 0): IT is not used and plays no part in teaching.
- Isolation (level 1): IT is used to teach students how to use IT (e.g. keyboarding, drill-and-practice, word-processing activities). There is no or little connection between IT and instruction content.
- Supplement (level 2): Teachers use IT to assist instruction and students use IT to aid learning occasionally. IT is viewed as a supplement to existing instructional program.
- Support (level 3): IT is needed to complete most learning activities. IT serves as a support to instruction.
- Integration (level 4): Students and teachers can use IT in every-day learning/teaching naturally, confidently, and actively. IT is expansively viewed as tool, process, method to find solutions to authentic problems in any time anywhere.

3.2 Curricula

For elementary and junior high schools, the curricular idea should be life-centered and be in compatible with the development process of students' physical and mental abilities; respect character development, inspire individual potential; cultivate civic qualities, respect the value diversified culture system; enhance science knowledge and skill, meet the requirements of modern life. The design of curriculum should be based on students, on practical experience, and devoted to cultivating the basic abilities required of modern citizens [11]. Therefore, the curriculum should be designed as student-centered integrated or interdisciplinary curriculum, not subject-centered separate curriculum.

IT is used as a tool to help students solve the problem. IT literacy should not be taught as an isolated subject, nor should activities with IT be isolated from other activities in the classroom [12]. Therefore, Taking the students to the computer lab once a week for 40 minutes is not necessarily integration [3]. The teachers should commit to designing student-centered integrated curriculum and integrate IT into the curriculum.

3.3 Learning Materials

Textbooks are the main materials for elementary and junior high schools and the primary learning materials of students. In traditional education, textbooks were unified, having only one version. They were based on subject systems and separate from students' living experience. Besides, it was difficult to innovate them,

they could not meet society's requirements for rapid transformation. In 1996 Taiwan implemented a policy which would partially allow publishers to edit and provide textbooks for elementary and junior high school so long as they are approved by the Ministry of Education. On February 3, 1999, VIII (2) of National Education Act was empowered, which unequivocally directs the full use of ministry-approved textbooks for elementary and junior high schools. A new epoch for textbooks was thus heralded in. Teachers should be able to exert their professional autonomy, and students should be allowed a flexible, autonomous learning leeway.

The presentation of learning materials should not be limited to static traditional books, but the characteristics of computer multi-media should be used to present these materials. Static words and pictures, animated pictures and films, voice, acoustic effect and music in combination would make teaching materials lively and motivate students to learn. Besides, they can help students to understand abstract concepts or knowledge and enhance learning effectiveness. If hyperlink technology is used, nonlinear learning materials can be designed so that what students see can be highly individual and not the same. As such, the content of learning materials is flexible, adaptive to individual difference, and compatible with the spirit of individualized learning.

In addition to textbooks, there are many resources on the Internet that can be used as learning materials. These resources can provide "instant", "living" information [8]. Teachers not only can search for information to be included in teaching materials but also can use the real-time information on the Internet to conduct teaching. Students not only can search for information on the Internet but also can conduct independent learning any time, any place by using the learning materials on the Internet.

The use of information technology can make learning materials diversified and lively, make their content flexible and integrated with life. Not only can teachers easily motivate students to learn, but students also can learn happily in a rich teaching situation.

3.4 Instruction Strategies

The teaching strategy of the traditional expository approach is teacher-centered. Students learn what is taught by the teacher, but are given a limited room for thinking, discussion, presentation and exploration. The teaching effectiveness is ostensibly good, and students' performance on examination seems impressive. Yet this approach contradicts the essence of education. In a series of meaningless learning process, what students learn is segmented memory that is extraneous to their experience and cannot be applied in practical situations of their daily life. Nor can they enjoy learning.

Constructive teaching strategy is student-centered. The teacher would first arrange a teaching situation to arouse students' motivation for learning and then would conduce students to explore and think. Through the interaction with peers, the students can gradually integrate the new knowledge into their own system of knowledge and make it an essential part of this system. By this constructive teaching, students must actively learn, while the teacher can only play the role of facilitator, auxiliary, and consultant.

When students use teaching software and browse for Internet resources, they must explore and think actively and construct their own knowledge through the interaction between machine and person and through social interaction. Therefore, the teacher is a "coach" for the student rather than a provider of knowledge. Self-directed learning is an attainable goal for both the student and teacher when IT is integrated in the various content areas [6]. That is, IT integration is most likely to occur in learner-centered classrooms in which the teacher acts as a facilitator [3].

3.5 Learning Activities

Traditional lecture-based and teacher-driven activities can no longer satisfy the needs of modern education. It is not only monotone, also lacks interaction between peers. Learning activities should be student-centered so that the learner can actively work to explore knowledge, clarify concepts, and gradually construct his/her system of knowledge. In addition, project-based and cooperative learning activities should be adopted to allow the learner the opportunity to produce high-level interaction with his/her peers. These activities not only can cultivate a respectful, responsible, and confident attitude and the abilities to express, communicate, coordinate, think, and create but also can increase learning effectiveness.

In cooperative learning activities, students can use computer to communicate and discuss, or use a certain

support cooperative work software to facilitate collaboration. Finally, multi-media would be used to present the learning effectiveness of students. Cooperative learning is not limited in local class. It can also be applied across schools, countries, and culture. Therefore, IT enriches the learning activity.

3.6 Evaluation

The traditional evaluation approach primarily depends on paper examinations and determines learning outcome by the scores on the test sheets. This type of evaluation measures only a dimension of knowledge, unable to reflect the wide spectrum of learning process. Future evaluation will become diversified; performance evaluation may be conducted along with paper evaluation; students' self-evaluation, peer evaluation and juried evaluation may be conducted along with teacher's evaluation; in addition to evaluating learning outcome, the learning process should be evaluated; in addition to quantitative evaluation, qualitative evaluation should be adopted; in addition to evaluating cognitive domain, the evaluation of affective and skill areas should be included. Only such a comprehensive evaluation can reflect the learning process, not only be able to understand what the student has learned but also be able to understand how the learning has occurred.

IT integrated instruction is helpful to the implementation of diversified evaluation. For example, the electronic portfolio is an ideal means of integrating IT into the instruction. It gives the student and teacher an alternative form of assessment. Furthermore, electronic portfolios motivate students to produce quality work, and they also increase students' self-esteem by showcasing their best work [6].

4 Assessing the periphery part

The periphery part primarily refers to the surrounding situations. Table 2 shows the perspectives and emphases to be assessed. The following illustration is based on perspectives.

4.1 Teachers

The teacher is vital in leading teaching activities. Without sufficient information literacy and professional ability, he or she cannot apply information technology on teaching, let alone implement IT integrated instruction. Regarding professional ability, the teacher should be able to integrate IT, in addition to assessing software and digital materials. The attitude is another emphasis of assessment. If the teacher has a positive attitude toward computer, he/she can readily introduce and apply computer on teaching; if the teacher can accept the change in teaching status and role, the implementation of IT integrated instruction would not cause a great impact.

4.2 Students

Students are the chief character in education. In teaching, students should take the initiative to construct their own knowledge. In implementing IT integrated instruction, students can obtain from the process related knowledge and skill and steadily strengthen their information disposition. Gradually students should be able to use, naturally and confidently, computer equipment in active learning and to construct their system of knowledge.

4.3 Information specialists

Teachers are not information specialists. In extensive application of IT to teaching, they will definitely encounter many technical problems that can not be solved by them. In this case, information specialists can support teachers in solving such problems. It is much easier for information specialists with education background to integrate IT with education and guide classroom teachers to implement IT integrated instruction.

4.4 Administrators

Whether administrators feel important about IT integrated instruction is intimately related with the implementation of IT integrated instruction. In addition, if the classroom teacher can gain sufficient administrative support, he or she will be more willing to implement IT integrated instruction.

4.5 Classroom Settings

Generally speaking, teaching activities are conducted indoors. Therefore, the IT equipment in classroom is indispensable to the integration of IT into teaching [14]. The computer and peripherals should not be outdated. The operation system and application software installed in the computer should be appropriate for the use by students and suit the needs of teaching. Moreover, for a class of more than 10 students, a large display device or broadcasting teaching equipment is needed. Finally, it matters whether they are managed properly or whether the fair use by students is ensured.

Table 2. Emphases of the periphery part to be assessed

Perspective	Emphasis
Teachers	Information literacy and professional competency Attitude toward information technology and instructional change
Students	Information literacy Attitude toward information technology
Information Specialists	Professional competency Support for teacher
Administrators	Attitude toward information technology integrated instruction Support for teacher
Classroom Settings	Number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripherals (e.g. printer, scanner, digital camera) Broadcasting teaching facilities Management
Computer Laboratories	Number of computer labs, number of computers and person-machine ratio Grades and fixtures of computer Operating system and application software. Peripheral (e.g. printer, scanner, digital camera) Broadcasting teaching system Management
Campus Instruction Network	Structure of campus network and network type Domain account File server and database server CD cabinet (perhaps made possible through software simulation)
Internet	Method and speed of Internet connection Actual connection speed Internet server (e.g. web server, proxy server, DNS server, mail server) The mechanism to filter out inappropriate information.
Digital Materials	Digital materials that can be used on the Internet Digital materials created by the teacher
Instruction/Learning Software	Quantity Adaptation

4.6 Computer Laboratories

In a situation in which IT is integrated into teaching, sometimes it is required that one person have one machine. Computer laboratories can justly meet this requirement. Therefore, the management of computer laboratories is an important assessment item and can decide whether the computer equipment can sufficiently support classroom teachers [14]. Moreover, computer laboratories can also provide the most appropriate places for teachers' advancement and students' training of information skill. The equipment in the computer laboratories should not be outdated. Furthermore, there must be a broadcasting system, enabling students to know the whole content of teacher' s lecture in a ready manner.

4.7 Campus Instruction Network

The planning and erection of campus instruction network aims not only to construct an instruction network on campus but also to enable every classroom on campus to connect to the Internet through the campus

network. After the campus network is erected, File Server and CD cabinet (perhaps made possible through software simulation) should be erected, in which the teaching software owned by the school is stored so that all the teachers of the school can access to it readily and can apply it to teaching. In addition, the establishment and management of network account is equally important, ensuring the safety of information [14].

4.8 Internet

There are unlimited, un-exhaustive teaching resources on the Internet. If computers can not be connected to the Internet, the application of IT to teaching is compromised. Therefore, it is very important to provide information settings of the Internet. In addition, it is needed to erect Internet-related Server, in particular, Web Server must be erected so that teachers' teaching information and the learning outcome of students can be stored on it to facilitate examination and simulation by teachers and students. Besides, Internet is full of erotic and violent information which is unsuitable to students. It is extremely important to build a mechanism to prevent students from seeing those inappropriate content [14].

4.9 Digital Materials

Digital materials may be presented through information equipment and be used in teaching activities. Therefore, plentiful digital materials should be able to help integrate IT into teaching of various subjects. Therefore many on-line materials on the Internet can be used for teaching purpose. To decrease the amount of time required for browsing and facilitate the use of the materials by teachers and students, on-line index and search systems are also required. In addition, if on-line materials are not appropriate for teaching needs, classroom teachers may create their own materials to be presented on information equipment or use materials created by colleague teachers with the approval from the original designer [14].

4.10 Instruction/Learning Software

Computer Assisted Instruction (CAI) and Computer Assisted Learning (CAL) software is a help to teaching and learning. With more software, teachers are better equipped to apply IT to teaching. This software should be stored on the CD cabinet or File server on the campus network so that teachers can readily use it whenever needed. In addition, if existing teaching software available on campus is evaluated, further information can be provided to teachers [14].

5 Conclusions

That teachers and students can extensively use computers for teaching or learning purpose to heighten teaching qualities and learning effectiveness is the ultimate goal of the infrastructure construction of information education [5]. In other words, integrating computer into teaching of various subjects is the ultimate goal of the Ministry of Education in promoting information teaching [13]. What IT integrated instruction means is not merely to assist teaching by computer but work to integrate IT into curriculum, learning material and learning activities. At this point, the role of teachers begins to transform, from that of a main character to that of a support character. Therefore, the implementation of IT integrated instruction not only harmonizes with the u ltimate goal of information education but also prompt the reform of education so that learning becomes more effective, efficient, and meaningful.

IT cannot be successfully integrated overnight. It needs to take years to complete the process. The process should be carried out in order, stage by stage. Taiwan's IT integrated instruction is germinating. The assessment framework set forth in this article can be used not only to carry out practical evaluation but also serve as reference for development. Teachers' in-service education, pre-service training, administrative support, enriching IT equipment, developing appropriate digital materials and teaching software should be taken to strengthen the perspectives of the periphery part and to diversify the surroundings so that teachers can realize the benefits brought about by IT on education, Accordingly, teachers can apply IT to teaching, gradually infuse IT into learning activities, curricula, learning materials, and adopt student-centered teaching strategies and multi-facet evaluation. All this can lead to the fulfillment of the meanings of IT integrated instruction.

References

[1] Chang, H. Y., "1999 review of implementation of infrastructure construction plan for information education by the Ministry of Education", Ministry of Education Computer Center newsletter, No. 8810, pp. 1-8, (1999).

[2] Chiu, K. H., "Concepts and methods of computer-integrated instruction", Taiwan Education Review, No. 479, pp. 1-8, (1990).

[3] Dias, L. B., " Integrating technology: Some things you should know", Learning & Leading with Technology, Vol. 27, No. 3, pp. 10-13, 21, (1999)

[4] Dexter, S. L., Anderson, R. E., & Becker, H. J., "Teachers' views of computers as catalysts for changes in their teaching practice", "Journal of Research on Computing in Education", Vol. 31, No. 3, pp. 221-239, (1999).

[5] Han, S. M., "Infrastructure construction of information education – acceleration", Information and Education, No. 68, pp. 14-16, (1998).

[6] Hanfland, P., "Electronic portfolios: Students documenting their best work", Learning & Leading with Technology, Vol. 26, No. 6, pp. 54-57, (1999).

[7] Her, J. K., "Viewing the prospects of information education in elementary and junior high schools from the promoting strategy of information education of the Ministry of Education", Information and Education, No. 68, pp. 2-13, (1988).

[8] Lee, C. M., Wu, C. J., & Lin, M. C., "Erection of information education software and material resources center", Information and Education, No. 68, pp. 21-28, (1998).

[9] Levine, J., "Planning strategically for technology integration", Proceedings of Technology and Teacher Education Annual 1998 (SITE ' 98), Charlottesville, VA, pp. 293-295, (1998).

[10] Mehlinger, H., "School reform in the information age", Phi Delta Kappan, No. 77, pp. 400-407, (1996).

[11] Ministry of Education, "Tentative Guideline for Nine-year Integrated Curriculum for Elementary and Junior High Schools (first learning stage)", http://teach.eje.edu.tw (accessed on April 13, 2000).

[12] Sprague, D. & Dede, C., "If I teach this way, am I doing my job: Constructivism in the classroom", Learning & Leading with Technology, Vol. 27, No. 1, pp. 6-9, 16-17, (1999).

[13] Tu, A. P. & Lin, H. H., "Accelerating the infrastructure construction of Taiwan' s information education: Alternative for expanding internal demand – special interview of Chen Li-hsiang, director of computer center of the Ministry of Education", Information and Education, No. 68, pp. 29-32, (1998).

[14] Wang, C. S., "Criteria for assessing information situation of information technology integrated instruction", Information and Education, No. 77, pp. 36-47, (2000).

An authoring shell with intelligent reuse

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Common authoring shell that enable reuse of teaching materials allows teachers to search for existing teaching materials on the web and computer system. The authoring shell will give a list of materials that will match the word(s) for searching. Sometimes none of the matched items will be reported but sometimes hundreds of matched items will be found. It is difficult for teacher to browse all matched items before making decision to reuse the material or not under such situation. To facilitate the reuse of teaching materials, we expect an authoring shell should be more intelligent—able to identify the purpose of the teacher in searching for a material. It should provide a list listing closely related materials when there is no matching and filter off those materials that are not related to a teacher's intention. In this paper, we shall discuss how it is possible to achieve this.

Keywords: **Reuse, authoring, intelligence**

1 Introduction

There is a lot of authoring tools available that assists teachers in producing online course. Common authoring tools being used by educational organizations to produce online course/lesson are Authorware, Toolbook, WebCT, BlackBoard, COCA and Hypercard ... etc. Most of these tools can help a teacher to create and manage web-based courses even though the teacher may not have any programming or web-based design experience. These tools are not domain specific and therefore can be used in various knowledge domains. Usually these tools do not explicitly specify the pedagogy or the teaching strategies. Thus, a teacher at authoring will not be bounded by specific pedagogy or teaching strategy in using these tools. But this also means that a teacher must plan and implement the pedagogy and teaching strategy by himself/herself before using the tool. Even though most of these tools allow a teacher to search and retrieve teaching materials, they do not actively support the reuse of teaching materials over multiple teaching strategies by giving suggestions to teacher.

IAS, Intelligent Authoring Shell, is a generic authoring shell prototype. Our initiative in building IAS is to enable reuse of teaching materials for multiple teaching strategies. By using IAS, the production of online adaptive course with multiple teaching strategies can be more cost-effective. It is named with "intelligent" because it will suggest closely related reusable materials to a teacher at authoring.

2 Hypothesis for reusing teaching materials

There are two basic ways in tackling reuse of teaching materials. One of the ways is based on ontology. In 1996, Mizoguchi and his fellows discuss using task ontology in building Intelligent Tutoring System where "Task ontology is a system/theory of vocabulary for describing inherent problem solving structure of all the existing tasks domain-independently" [12]. Laresgoiti [11] also examine the use of ontologies as "vehicles for reuse". They use application ontology, domain ontology, basic technical ontology and generic ontology to describe the physical world of education. Similarly, Murray [13] has also discussed using special purpose ontologies over object to describe pedagogical knowledge. In 1998, Mizoguchi and his fellows Chen [2] have extended the use of task ontology into domain ontology, teaching strategy ontology, learner model

ontology and interface ontology into their SmartTrainer authoring tool. Using ontology has the advantages on re-engineering the structure of knowledge in education and each knowledge domain. This will facilitate the use of information technology onto education. However, using ontology in authoring has a potential problem—most users, teachers are not familiar with ontology. Unless the operation of ontology is transparent to teacher at authoring, it is reasonable that teachers may be reluctantly to use such authoring tool. Using ontology aims to standardise the terms to be used so that everyone using ontology will have the same understanding on the term being used. However, in education, teachers are encouraged to provide innovative teaching in order to promote teaching and student's learning. Therefore, there exists problem between standardisation and innovation.

Another way to solve material reuse is by using a database repository to store teaching materials information. Sarti and Marcke [14] have discussed using database repository method in storing information about "Domain", "Structuring", "Instructional" and "Presentational" perspective inside DISCourse. Cybulski and Linden [3] also suggest using repository method to store the information about various kind of "artefact". They have identified some attributes for the artefact: artefact number, URL, type, label, content description, keywords, file type, file size and preview [4][5] in building their MATE tutoring system. Using a database has the advantages that teaching materials can be decoupled from the teaching strategies. Besides, it allows flexible courseware configuration over LAN and web. Since there are many good off-the-shelf database tools available, relatively it is much easier to store, retrieve and maintain teaching materials within the system. The disadvantage in using database are the additional cost in setting up and maintaining a database system and inherit the limitations from using database softwares.

Instead of using ontology, we have decided to use database system method to store useful information. Unlike methods used in MATE, we use learning objectives as the key to reuse on teaching materials. Most teachers are familiar with the concept of learning objective and there is a rich educational research literature surrounding them. Even though we know that there are still controversial arguments over using of learning objectives, we believe that there are more pros than cons in using learning objectives, particularly under the criteria of "effective learning" -- student using minimum time and/or effort to produce maximum learning outcome.

Basic learning objective has two main components: an *object* and a *keyword*, the letter drawn from a learning objective. An *object* is a concept, or skill, or entity that is described in a learning objective. For example, in a learning objective *"Define Newton's First Law"*, Newton's First Law is the *object*. *Keyword* is the verb being using in the learning objective. Refer to previous example, "*Define*" is the *keyword* of the learning objective. There has been a lot of educational research on *keyword* (also named as learning objective taxonomy). If each teaching material is tagged with at least one learning objective, then from the *object*, we can search for the existence of a related teaching material. Also, from the *keyword*, we can know the purpose of that teaching material. In our IAS, teaching material is a multimedia file corresponding to the "atomic artifacts" as defined by Cybulski et al.

Besides using learning objective over reuse at teaching material level, we can also extend the usage of learning objective to learning activity level and lesson level. Learning activities in IAS are activities such as introduction, exercise and conclusion that are defined inside a normal lesson structure. Lessons in IAS are set of learning activities that are organized for particular teaching strategy such as lecturing, case study, drill and practice …etc. The fundamental difference between our IAS and Cybulski's MATE system is; in MATE; learning objective is just a statement indicating the usage of teaching materials. In our IAS, learning objective is the key for us to build "*domain*", "*structuring*", indicator for usage, and "*glue*" to link teaching strategies and other educational theories into tutoring systems.

3 Design of IAS

In our IAS, we have built following modules: keyword (taxonomy) module, strategy design module and course design module. Reuse of teaching materials occurs in course design module. Keyword module and strategy design module provide the basic environment that help to provide intelligent suggestions to a teacher at authoring. Figure 1 shows the structure of our IAS.

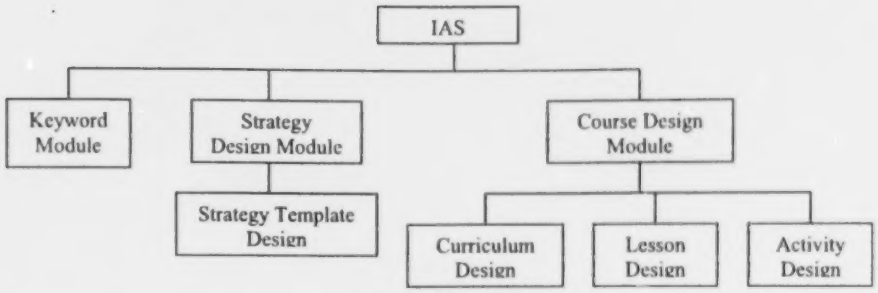

Figure 1 Structure of IAS

3.1 Keyword (Learning objective taxonomy) module

We have built this module to facilitate entering of learning objective taxonomy (*keyword*) into our IAS database. In building this module, we have used Bloom's taxonomy [1] as reference as it is a well-known taxonomy being used in education. In general, learning objectives [6] can be grouped as general objectives and specific objectives. General objective is composed of a set of specific objectives. Each specific objective can be composed of a set of sub-specific objectives or directly related to a lesson or an activity. Bloom has classified learning objective taxonomies into three different domains: cognitive domain, affective domain and psychomotor skill domain. Under each domain, taxonomies are further classified into different levels. For example, within cognitive domain, taxonomies are classified into *knowledge*, *comprehension*, *application*, *analysis*, *synthesis* and *evaluation*. These different levels form the class hierarchy with *knowledge* be the lowest class while *evaluation* is the upmost class.

In building this module, we are aware that Bloom's taxonomy is not the only taxonomy available. There are Harrow's taxonomy [7] on psychomotor skill, Krathwohol's taxonomy [10] on affective domain, Steinaker's taxonomy on experiential learning etc. Therefore, this module allows teacher to enter sets of taxonomy from other educational theory school such as experiential learning or "learn by doing". This feature will allow educationists to research and create their own set of taxonomy such as task ontology. We have also added a comment field for each keyword so that the definition of each keyword can be added. This will not only help teachers to arrive a common understanding of the keyword, but also in learning keywords from different educational theory school. Figure 2 shows the data hierarchy being used in this module.

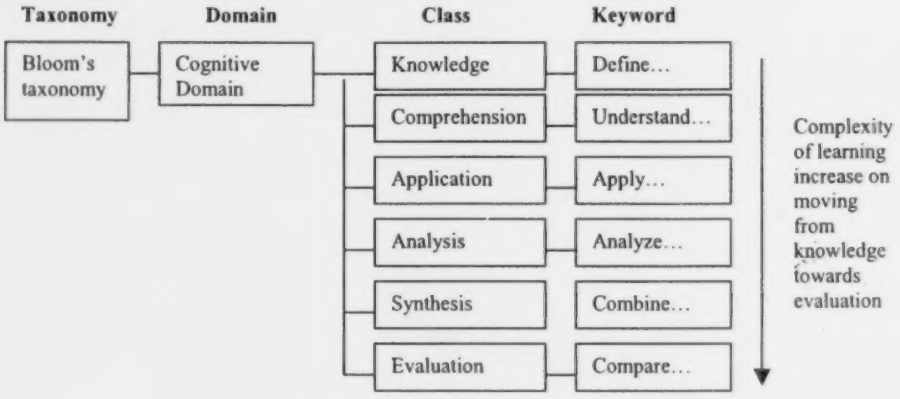

Figure 2 Bloom's hierarchy of learning objectives on cognitive domain

3.2 Strategy design module

From education, there are many teaching strategies such as lecturing, feedback lecturing, concept attainment, drill and practice, role-play, gaming, debate etc. Therefore, it is impossible to pre-design all teaching

strategies into our IAS. Besides, as mention before, teachers are encouraged to create teaching strategy or modify existing strategy in order to provide innovative teaching. Therefore, it is not reasonable if an authoring shell cannot allow a teacher to create his/her own teaching strategy. In IAS, we have a strategy design module that allow teachers to create their own teaching strategies. Using the strategy design module, we have pre-designed some teaching strategies such as lecturing, concept attainment for the purpose of demonstration and testing.

In IAS, a teaching strategy is composed of a set of activities with different activity type. Each activity type may consist of sub-activity type. For example, a lesson using concept attainment [8] as its teaching strategy usually contains introduction, example, counter-example, analysis and conclusion. A lesson using lecturing as its teaching strategy contains introduction, presenting new knowledge, example(s), exercise(s) and conclusion. Example is composed of sub-activities: description, question, answer and explanation [9]. Therefore, in designing a teaching strategy, a teacher will be asked to construct the structure for the teaching strategy by entering and arranging the activity types in order. Figure 3 shows a teaching strategy structure for lecturing.

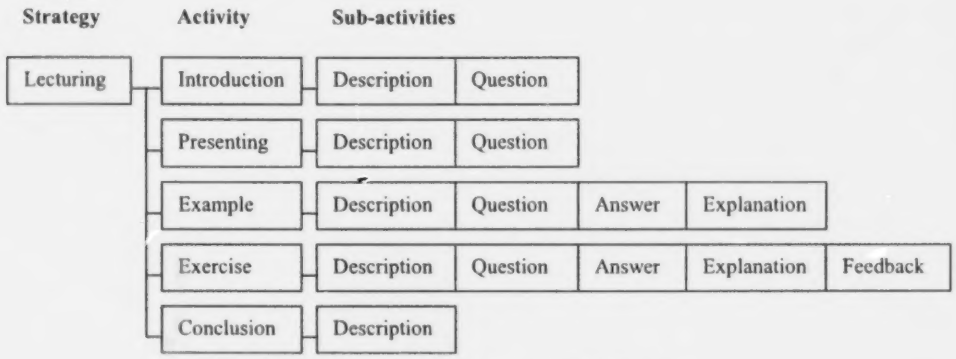

Figure 3 A teaching strategy structure for lecturing

In designing the structure of a teaching strategy, the author can enter information or rationale about using this teaching strategy. This will help other teachers in learning/knowing how to use the teaching strategy "properly". Author of teaching strategy is also asked to relate his/her teaching strategy to the domain and class of taxonomy that is unlikely applicable. With this information available, IAS can give suggestion to teacher what kind of teaching strategy are available and possibly applicable according to the keyword being used in learning objective.

3.3 Course design module

In designing a course, a teacher will be involved in designing the curriculum for the course, designing the lesson and the learning activities within each lesson. Since IAS is just an authoring shell, we will not consider the design of teaching materials. Authors can use most off-the-shelve multimedia authoring tools to create those teaching materials. In IAS, course design module is the module where most of the reuse of teaching materials takes place.

3.3.1 Designing the curriculum

In designing the curriculum, a teacher is required to construct a hierarchy of learning objectives for the course. A teacher will enter details for a learning objective including the keyword and object.
To enter a learning objective, a teacher will be requested to enter the object of the learning objective. With the object defined, a list of existing learning objectives with the same object will be displayed for selection. If a teacher want to put in a new learning objective, then a teacher will need to specify the keyword. Along with the keyword, the taxonomy, domain and class will be identified. Instead of keying in the keyword, a teacher may select keyword start from selecting the taxonomy, then domain and class. Information about the keyword will be displayed as required.

In entering a learning objective, it is possible for IAS to provide some basic logical checking over the

sequence of learning objective using the keyword class hierarchy. For example, it is not logical to arrange "apply for-loop" before "define for-loop" because, according to Bloom's taxonomy, "apply" is a keyword in class *application* while "define" is a keyword in class *knowledge*. Higher order classes usually require lower order classes as prerequisite. An illogical order of learning objective hierarchy will increase student's difficulty in learning. Therefore, such a checking feature can help to improve quality of a course.

After the learning objective hierarchy is built, an object hierarchy is also constructed using the objects from each learning objective. With this object hierarchy, we can identify the relation between each object. This relation will be useful in deciding which teaching materials may be appropriate for reuse. Besides, this will also assist us in searching and retrieving materials for the object.

3.3.2 Designing the lesson

In IAS, each lesson belongs to only one specific learning objective and each lesson has only one teaching strategy. However, a learning objective may have multiple lessons, hence multiple teaching strategies. With only one specific learning objective per lesson, it will be easy to replace a lesson with another lesson that has the same learning objective, thus provide multiple teaching strategy to student at learning. For example, if learning objective "Define for-loop" has two lessons designed using lecturing and concept attainment individually, then a student can decide to learn the learning objective using either lecturing or concept attainment or even both. Single learning objective per lesson also has the benefit that any modification of a lesson will not affect the other learning objectives.

In creating a lesson, a list of existing teaching strategy for the same learning objective will be available to teacher for selection. Besides, that, another list of appropriate strategy (with no activities defined) will also be available for a teacher to create his/her new lesson. This appropriate strategy list is generated according to the unlikely appropriate strategy for the class of domain keywords as mentioned in the "Strategy design module". For example, in knowing that the lesson is about learning a concept, IAS will give suggestion to the author indicating lecturing and concept attainment is recommended. Since IAS only provides suggestion rather than making the decision for the author, the author still can select other "less appropriate" teaching strategies available. With this feature, a teacher is allowed to use innovative teaching in preparing online courses.

3.3.3 Designing the learning activities

After a lesson is created, the author will follow the structure of teaching strategy to design learning activities. A learning activity may have sub-activities. For example, an example contains sub-activities description, question, answer and explanation. For activity that does not have sub-activities, author will be asked to enter the link (URL of the teaching material) to the activity.

In designing the learning activities for a lesson, basically it will use the information about the object and the keyword. From the preliminary analysis on reuse [9], we know that teaching materials in activities such as example and exercise are highly reusable. Therefore, in suggesting reusable learning activities, IAS will include activity type as a factor for consideration. The suggestion criteria available are based on activity type, keyword, object and learning objective (keyword + object). Suggestion criteria based on activity type will use activity type as filtering element. For example, if the activity at authoring is an example, then IAS will only list those activities that are examples only. Suggestion criteria based on keyword will list materials will the same keyword. However, this will give a large number of suggestions that are irrelevant due to the irrelevant object. Suggestion based on object only will give better results than using activity or keyword only because it always return closely related materials with same object. However, there are situations where IAS can not find the exact matching of keyword. Under this situation, IAS will give suggestion according to the "distance" from the object to other object on the object hierarchy as defined from the curriculum designed module. This will enable the most relevant activity/material will always be suggested. Suggestion criteria based on learning objective (keyword + object) will not only list materials/activities that have the exact matching on learning objective but also the activities/materials in the order of their relation in learning objective hierarchy (curriculum). This will reduce author's time in searching for reusable teaching materials, particularly when the database has thousands of teaching materials available.

4 Conclusion

An authoring shell that supports reuse of teaching material should not only allow the author to search for the

existence of the material and retrieve it if available. An authoring shell can be more "intelligent" by providing suggestions to author at authoring. Even if the searching cannot find the exact matching, an intelligent authoring shell should be able to produce a list of materials that are closely related to the searching. Our IAS is design not only to enable material reuse but also to assist author in reusing teaching material.

In our IAS, we have included a Keyword Module and a Strategy Design Module to provide the background for the intelligence. In the Course Design Module, an author can design the course curriculum, lesson within the course and activities for each lesson. IAS will provide intelligent suggestions to the author at each stage of design.

There are still a lot of works that we are going to do in order to improve the performance and intelligence of IAS. For example, we are going to find out whether there is an optimal suggestion criterion. Besides, we are also investigating the possibility for the IAS to continuously optimise its suggestions by itself according to a teacher's selections at authoring and students responses at learning. We know that Keyword Module and Strategy Design Modules cannot provide the complete background for the intelligence to be required. We still need to explore other modules such as pre-requisite knowledge module into consideration to enhance the performance of IAS.

References

[1]Bloom, B. S., M. D. Englehart, et al., "A Handbook of educational objectives: The cognitive domain", New York: David McKay, Inc., (1964).

[2]Chen, W., Y. Hayashi, et al., "An Ontology-based Intelligent Authoring Tool", ICCE'98, Beijing, China, China Higher Education Press Beijing, (1998).

[3]Cybulski, J. L. and T. Linden, "Composing Multimedia Artefacts for Reuse", http://www.dis.unimelb.edu.au/staff/jacob/publications/plop-98/pre-workshop-draft.pdf (accessed on February 1, 2000).

[4]Cybulski, J. L. and T. Linden, "Designing Multimedia Development Environments with Reuse in Mind", http://www.dis.unimelb.edu.au/staff/jacob/publications/acis-99/paper.pdf (accessed on April 2000).

[5]Cybulski, J. L. and T. Linden, "Assisting Web Site Development with Reuse and Patterns", http://www.dis.unimelb.edu.au/staff/jacob/publications/www-99/draft.pdf (accessed on March 1, 2000).

[6]Gronlund, N. E., "Stating Objectives for Classroom Instruction", Macmillan Publishing Company, (1985).

[7]Harrow, A. J., "A Taxonomy of the Psychomotor Domain", David McKay Company, INC., (1972).

[8]Joyce, B. and M. Weil, "Models of Teaching", Prentice Hall, Inc., (1986).

[9]Kam Wing, L. and J. Warren, "Reusing of teaching materials for an intelligent tutoring system with multiple teaching strategies", ICCE'98, Beijing, Springer-Verlag (1998).

[10]Krathwohol, D., B. S. Bloom, et al., "A Handbook of educational objectives: The affective domain", New York: David Mckay, Inc., (1968).

[11]Laresgoiti, I., A. Anjewierden, et al., "Ontologies as Vehicles for Reuse: a mini-experiment", http://ksi.cpsc.ucalgary.ca/KAW/KAW96/laresgoiti/k.html (accessed on May 16, 1999).

[12]Mozoguchi, R., K. Sinitsa, et al., "Task Ontology Design for Intelligent Educational/Training Systems", http://www.ei.sanken.osaka-u.ac.jp/pub/miz/miz-its96.html (accessed on August 1, 1999).

[13]Murray, T., "Special Purpose Ontologies and the Representation of Pedagogical Knowledge", http://www.cs.umass.edu/~tmurray/papers/ontology/ontology.html (accessed on August 1, 1999).

[14]Sarti, L. and K. V. Marcke, "Reuse in Intelligent Courseware Authoring", http://www.pitt.edu/~al/aied/sarti_vm.html (accessed on August 1,1999).

An Educational Application of Integrated Route Information Service on the Internet

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With the rapid growth and transfusion of information technology into community, the Internet offers a possible new education dimension. It provides a vast and integrated resource for individuals by network connecting and web interaction without time and location limitations. This paper presents an educational web system of integrated route information service (IRIS) that recommends and guides students to learn in-depth information of popular tourist spots and to travel those spots via the multimodal public transportation systems. As a result, the issues of environmental protection in terms of air pollution and traffic jam are overcome by making use of the proposed system, and the learner is also able to further understand local cultures and transportation information of his living area. The proposed IRIS educational service is categorized as a combination of transmission and consultation typology based on the controllability of information providing and distributing. The design of the system and its efficient algorithms for providing the service through the Internet will be discussed within the framework of the typology.

Keywords: **web application, transmission, consultation, Integrated Route Information Service**

1 Introduction

Traffic congestion and air pollution have become major headache for most large cities around the globe. Millions of people waste their time in jammed traffic and keep making air polluted by exhaust emission everyday. Driving in jammed traffic can also make people very annoyed and tired, inevitably reducing people's productivity and devastating state of mind when they finally arrive at their destination. As a result, educating people to utilize public transportation systems has become a target for all modern countries, and the Internet is one of the best approaches to convey the information and to achieve the goal.

The congestion problem can be tackled from both the demand and the supply sides. From the supply side, one may build more roads to increase the total capacity for traffic. This approach, however, may not be practical for many countries and definitely will ravage the natural environment. Land is a kind of limited resource, so we cannot construct more roads at the speed that people can buy more cars.

There are several conceivable strategies to cope with the traffic congestion and air pollution problems from the demand side. For instance, we may reduce the traffic volume and air pollution by legislatively banning a portion of registered vehicles from entering cities on specific days as what Singapore employs or aggravating car taxes for the aged cars as Japan does. Another strategy to reduce the traffic demand is to encourage people to commute by public transportation systems. Convenient public transportation systems provide not only an economical way for people to commute but also a chance for us to alleviate the air pollution problem that results from excessive use of passenger vehicles.

A popular way to encourage and educate people to use public transportation systems is to provide complete route information and to improve the predictability of travel times in an efficient and effective approach. Most noticeable measure is the introduction of bus priority routes in many cities [2]. By granting buses

exclusive rights to run on chosen routes, people can estimate the travel times on buses more precisely, thereby offering an incentive for people to take advantage of buses. Typical multimodal public transportation systems provide a complex route network for people to move around the cities. The route network covers the served area such that people can virtually walk to their destinations within minutes after departing from a nearby bus station. Complex route network, however, is very difficult for people to figure out what routes of buses they should take to get to their destinations. Taking the public transportation systems in the Taipei metropolitan area for example, more than 200 bus routes serve the metropolis, and the number of bus routes is still growing. A railroad route crawls through the metropolis, and five subway routes connect very busy area in the metropolis. Searching the best way, or even just a good way, to travel via such multimodal public transportation systems can be very challenging to ordinary people.

Providing route information is certainly an important step toward promoting the use of public transportation systems. People will not use the transportation systems effectively unless they have a good idea of the service provided by the systems, and people will stop using public transportation systems if they cannot use the systems effectively. We are motivated by this observation to build an information service that can help people find out their ways in such multimodal public transportation systems in order to solve the problems of environmental protection.

To this aim, we build a web service that provides Integrated Route Information Service (IRIS) to commuters and travelers. We collect route information of buses, subways, and trains that serve the Taipei metropolitan area, and maintain the collected data with a standard database management tool. Users of IRIS can request recommendations through Internet for how to use public transportation to travel from one location to another in the metropolis. Using informed-search methods [3], IRIS searches for paths and recommends selected paths to users via web connection in a real time manner. The recommendations may provide one or more ways to travel between the chosen locations, each of which may require users to transfer among different modes of public transportation systems, e.g., from buses to buses, from buses to subways, and from subways to buses.

IRIS system is considered as a travelers' guiding center that provides the information of sight-seeing spots and complete travel advisories in transportation. The techniques we employ to build the IRIS for Taipei city can be applied to provide similar services in any other metropolis. In a longer run, we can expand the database of IRIS to make IRIS a part of the intelligent transportation systems that will modernize the transportation systems in Taiwan or other countries[4].

2 Taipei public transportation systems

There are three basic types of public transportation in Taipei: trains, buses, and rapid transit system. Taiwan Railway Administration (TRA) operates traditional train system that runs through the heart of the metropolis, and there are a half dozen of stops in the area. We can obtain train schedule from both the booklet published by the TRA and its web site [10]. The Taiwan High Speed Rail Corporation [9] and the central government plan to build a high-speed train system that will connect major metropolis on the island, but the system will not start to operate in the near term.

Several bus companies, including publicly and privately owned ones, jointly operate the Taipei bus systems. These companies serve more than 200 bus routes in the city, and their routes altogether have about 2500 stops distinctively. Various sources of bus-route information are available nowadays. Traditionally, people obtain bus-route information either from booklets or from signboards at bus stops that contain such information. Those booklets can be purchased from any book retailer island wide. Recently, the Internet brings us a convenient media for distributing bus-route information. The Taipei city government provides on-line bus-route information on its web site [6,7], and there are personal web sites that provide free route information as well.

The Taipei Rapid Transit Corporation (TRTC) operates the Taipei Rapid Transit system (TRT). People may find information related to the TRT from both brochures published by the TRTC and its web site [8]. The TRT system consists of five different color-coded routes and there are four special locations where people may transfer between subways, traditional trains, and buses. They include Panchiao, Lungshan Temple, Sungshan and the Taipei Main Station that lie at the intersection of the red and the blue lines.

A traveler obtains the complete information through Internet for each type of public transportation

respectively, however, he may not be able to conclude the best vehicle combination for a specified original/destination pair for himself. Therefore, he may result in giving up the usage of public transportation and drive his own vehicle instead, and perhaps the air condition will be devastated in a further step. In the following section, we introduce the methodology of collecting public transportation information for each type and propose an efficient and intelligent algorithm for an optimal combination via Internet access in real time. A traveler can access the web site to learn the best way to arrive his destination by public transportation system.

3 Route-information database

3.1 The raw data

Information from multiple sources can cause data inconsistency problem. Both TRA and TRTC provide authoritative information about the routes that are under their control. Since TRT and traditional trains typically do not change routes, it is easy to take care of route information about these systems. Bus routes, in contrast, can change from time to time due to a variety of reasons such as road construction and demonstration events, etc.. Also, route-information sources, both web sites and books, typically do not reflect the route change in a timely manner. Our experience indicates that chance is high that bus-route information provided by different sources does not completely agree with each other.

Fortunately, bus companies generally do not change bus routes randomly. Usually, bus stops are relocated to nearby locations. Providing information that becomes out-of-date because of such minor route changes might cause nuisance, but the routing information should remain valuable. Therefore, we adopt the route information that is recorded in a booklet [5] in building our route-information database.

We maintain route information about buses, TRT and trains in a similar way. Tables for all routes contain the departure, intermediate, and destination locations in the metropolis. Routes served by different systems are marked by an attribute, *type*, in the route table. Each route table contains the type, the route number, and names of the departure, intermediate, and destination stops. The intermediate stops are *ordered* according to when a passenger may pass the stop from the departure stop, so a stop will have an *order* attribute in the database. Since regular routes that connect a particular pair of locations, A and B, typically provide round trip service, we treat routes that go from A to B and that go from B to A as two different routes.

We construct stop tables based on these route tables for convenience of reference. Each stop table contains what routes are available, the order of the stop on these routes, and if TRT and traditional trains are available at the stop. For further processing of the raw database, we also include information about the longitude and latitude for each stop in the database, and which will play an important role for geometrical information retrieval or WAP application in the near future.

3.2 A hierarchical map

We preprocess the raw database for the route-planning algorithm. Let X and Y be different stops, we use the following terms in the discussion.

(1) Stop route and *stop size*: In practice, a stop is a small area in the metropolis, and typically one or more routes may allow passengers to get on and off at a stop. The stop route, denoted $SR(X)$, is the set of the routes that serve the stop X, and the stop size of a stop X, denoted $SS(X)$, is the number of routes that serve the stop X. Notice that the routes can be either bus, TRT, or traditional train routes.

(2) Stop distance: The stop distance between X and Y, denoted $DS(X,Y)$, is the minimal number of intermediate stops that we would pass if we travel from X to Y via public transportation.

(3) Geographic distance: The geographic distance between X and Y, denoted $DG(X,Y)$, is the Euclidean distance between X and Y.

As we inspect the stop tables, it becomes clear that some stops are relatively more convenient in terms of ease of transferring between routes and are denoted as hubs. These *hubs* should be seriously considered as transfer centers when there is no direct route connecting the traveler's origin and destination. The Taipei Main Station, for instance, provides a great chance for people to transfer to routes that eventually lead to their destinations.

To take advantage of this observation, we introduce an attribute in the stop tables to reflect that if a stop is considered as a hub according to its easiness of transferring. To this end, we consider stops that have TRT and train services as hubs. Currently, we set the hub attribute if the stop size of the bus stop is greater or equal to 15. Therefore, in addition to TRT and train stops, we have about 70 hubs for Taipei area in our database.

We annotate tables for each stop X with information about the *nearest hubs*, denoted *NH(X)*. A nearest hub of a stop X is a hub that can be reached by taking a particular route in *SR(X)* from X. Clearly, if a stop is itself a hub, then the stop is also the nearest hub for all routes in *SR(X)*. Except this trivial case, we define the nearest hub B of a stop X on a specific route based on the following criteria that are listed in the descending priority.

(1) DS(H,X) ≥ DS(B,X) for any hub H
(2) If DS(H1,X)=DS(H2,X), then B=H1 when SS(H1)>SS(H2) and B=H2 when SS(H2)>SS(H1)
(3) When there are still multiple candidate, we let B=H1 if DG(H2,X) ≥ DG(H1,X).

Usually, the first criterion suffices for determining a nearest hub on a route from X because most routes pass a hub or two. When a route from X does not pass any hub, transferring to other routes will be considered, and this is when we may need these criteria.

To speed up the route-planning algorithm, we have done some preprocessing on the raw database. We add into each stop table the routing information between the stop and its nearest hubs. This extra information will be helpful when we need to transfer via nearest hubs. Also, we compute routing information between any TRT and traditional train stations, and save the results in the route-information database. This information can be very useful at runtime, but does not require a large space to save, so it is worthwhile to carry out this preprocessing offline.

Technically speaking, the route map in our database has two levels. The lower level consists of all stops, and the higher level consists of only hubs in the metropolis. To utilize this hierarchical organization, we compute the best ways to travel from hubs to hubs offline, and save such information in the database. We will see how the route-planning algorithm harnesses such an effort next.

4 The route-planning algorithm

Although the route-planning algorithm does not necessarily provide the fastest solution for traveling from origins to destinations, the algorithm does attempt to do so based on a few heuristics. First, the algorithm strongly biases for the use of TRT and traditional trains.* It typically takes less time to commute by TRT or trains than by buses between two locations. The algorithm also prefers solutions that require less transfer and less number of intermediate stops. Therefore, the algorithm prefers a routing method that needs only one transfer to one that needs two transfers. In the algorithm we define and compute at runtime the set of stops *R(X)* that are directly reachable from a stop X via *SR(X)*.

The algorithm requires information about the desired origin and destination. At this moment, both origin and destination are names of stops, so the algorithm does not have to worry about cases where no connecting routes are available. There is an easy way to expand the algorithm to allow street addresses as input for origin and destination since our stop tables already have the information about the longitude and latitude of each stop. The skeleton of the algorithm follows.

Algorithm RoutePlanning(origin O, destination D, route-info database)
1. If O is equal to D, there is no need to commute.
2. **Direct link**: If the intersection of *SR(O)* and *SR(D)* is not empty, there are ways to go from O to D directly, and the algorithm recommends such direct paths. If both O and D are TRT stops, recommend the TRT first.
3. **One transfer**: If D is in *R(R(O))*, we may go from O to D with one transfer, and the algorithm recommends these paths.

* For simplicity, we will not distinguish between TRT and traditional trains henceforth.

4. **Transfer via hubs**: Recommend the path from *O* to its nearest hubs *NH(O)*, from *NH(O)* to *NH(D)*, and then from *NH(D)* to *D* .
5. **Sorting and listing**: Sort and list the possible route combinations based on stop distance *DS*(*O*, *D*) and stop size of transferring node *SS*(*X*).

Whenever the algorithm finds multiple solutions to the query, it orders the solutions by the total number of intermediate stops. This designed decision is based on the assumption that more intermediate stops may lead to a longer total travel time. This principal may apply to solutions found at any step. For instances, at the second step, the algorithm may find multiple bus routes that directly connect *O* and *D*, and these routes will be listed in the order of increasing number of intermediate stops between *O* and *D*.

When there is no direct way to commute from *O* to *D*, the algorithm continues to the third step. This step dictates that commuting from *O* to *D* needs one transfer if there is at least a stop *Z* in the set of *R(O)*, and *D* is in the set of *R(Z)*. We can thus infer that it takes just one transfer to go from *O* to *D* if the intersection of *R(O)* and *R(D)* is nonempty. This method may be a good heuristic, but is not flawless. Recall that *R(Y)* represents the set of stops that are directly reachable from *Y*. The fact that the intersection of *R(O)* and *R(D)* is nonempty implies that there is a route from *O* to an intermediate stop *Z* and another route from *D* to *Z*. There is no warrantee to find direct routing method from *Z* to *D*, which is what we really need. There must be a stop *X* that can be directly reached by a route, say *RA*, from *O*, and must also be directly reachable by another route, say *RB*, from *X* to *D*. The algorithm will frequently find many related one-transfer solutions, and some of them appear to be better than others. Consider commuting from *A* to *B* in the example shown in Figure 1. Since there is no direct way to go to *B* from *A*, we must transfer at *T1*, *T2*, or *T3*. This might appear to be a contrived example, but it is not. In reality, bus routes often pass a portion of business districts, so they tend to have a few consecutive common stops. Examining these three alternatives for transfer, we see that the traveler can only transfer from *R1* to *R2* at either *T1* or *T2*. The traveler will have two choices, *R2* and *R3*, if s/he transfers at *T3*. Therefore, *T3* appears to be a better choice for transfer because it provides better chance for the traveler to catch the next bus sooner. Due to this observation, our algorithm lists as better alternatives those stops that have larger stop sizes for transfer.

When there are neither direct nor one-transfer routes that connect *A* and *B*, the algorithm reaches the fourth step. At this step, the algorithm applies the information contained in the database about nearest hubs of *A* and *B* to find desired solutions. Recall that we have computed the best routes from *A* to its nearest hubs *NH(A)* and the best routes from *NH(A)* to any other hubs including the nearest hubs *NH(B)* of *B*. The remaining task is to find a route from *NH(B)* to *B*. This is not a difficult task in practice since we can find at least a stop *X* in *NH(B)* such that *B* is in *R(X)*. Figure 2 illustrates that, to commute from *A* to *B*, we can commute from *A* to one of its nearest hubs, *H1*, then to one of *B*'s nearest hub, *H3*, and finally to *B*. In this case, the route-information database will contain the best way to commute from *H1* to *H3* is via *R1*, and the best way to commute from *H1* to *H3* is via *R1* and then transfer onto *R6* at *D*.

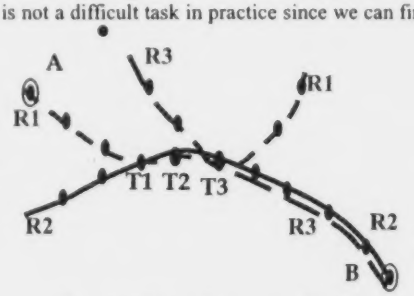


Figure 1: T3 is a better transfer location

5 User interface

In addition to provide intelligent public transportation information, the IRIS system collects general travelling information at Taipei, and it also provides information about popular tourist spots including natural beauty, cultures (museum/memorial/temples and historical sites/festival/folks art /aboriginal art/towns and city), amusement parks, shopping and entertainment, food and beverages, real-time weather report, real-time traffic surveillance, and related travel services. All these services and introduction are categorized and constructed in

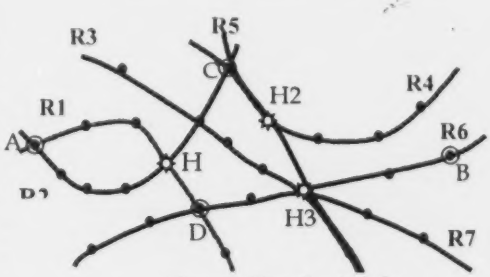


Figure 2: Transfer via hubs

the way of friendly and graceful page design. Unlike the consultation typology of public transportation querying system, the design pattern of travelling information leans to one-way communication of media technology. The activities of users are pure reception, and the pattern of communication is categorized as a transmission typology.

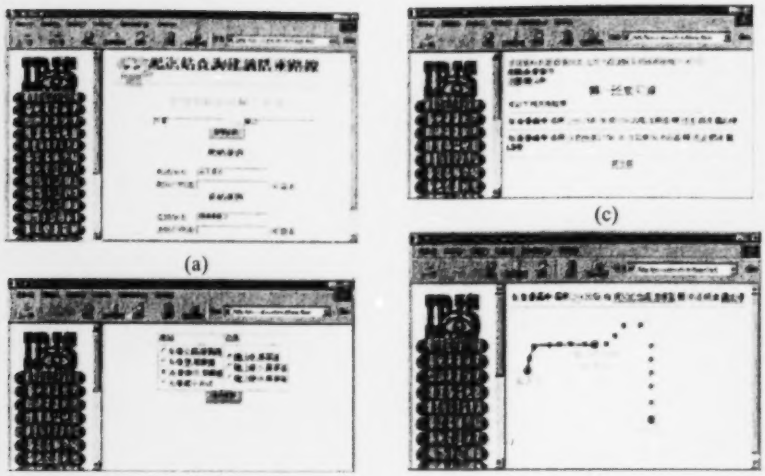
To obtain the quickest route information of an area or spot, users can click one of following items listed to acquire the correlative information: route information (complete stop information for each bus/TRT/TRA route), stop information (complete bus-route information for each bus route), local area route information(complete transportation information for each local area), popular tourist spot route information(complete transportation information for each tourist spot), original/destination Integrated Route Information(complete route information from original to destination). All these items are designed as a format of consultation typology and users have to make a request to the information providing center for specific message to be delivered. For examples, in the application of original/destination Integrated Route Information, users are allowed to type partial text of original/destination information through the main interface, and the IRIS system will base on the input contents and response an interface with option selection buttons for complete inputs. After analyzing the selected original/destination location buttons, IRIS system will verify the data, execute the matching programs, and show the results by listing route numbers and transfer stops in different color text, and the system also provides the map information of selected route and stops respectively. The querying processes and results are displayed in Figure 3. Listing the results with text may allow the system to provide more alternative routes at a time, but showing the routes on the map gives travelers a clearer picture of the recommended routes. The system is welcome to access and evaluate through the web address http://iris.cs.ntou.edu.tw/.

6 Conclusions

The proposed educational service is categorized as a combination of transmission and consultation typology. The part of general travelling information of IRIS system which provides and controls information distribution serves as a transmission communication pattern. When the learner makes a request and system provides an integrated information immediately, the system performs as a consultation typology since the information is produced by the system but the learner retains control over what and when the information is distributed. The objective of the proposed web services is to provide an integrate and optimal solution for tourists, however, there are still some future work left to be completed in this project. As we have reported, the IRIS system prioritizes alternative solutions based on heuristics that take into account the number of intermediate stops and times of transfers. Although these may arguably be good rules of thumb for selecting fast routes, a traveler might prefer routes that minimize the total distance that s/he would travel. To provide such alternative, the system would have to know the actual distance traveled by the bus for moving between two consecutive stops. In a longer run, the IRIS system may allow travelers to determine if the system should prioritize alternative solutions by the monetary cost, frequency of buses, and even predicted travel time.

The path-planning algorithm reported in Section 4 prefers the travelers to transfer at a stop that has a larger stop size. This designed decision is based on easy of transferring to another bus. Travelers may have other concerns though. A traveler might prefer to transfer at previous stops because it is more likely to have a seat if one can get on the bus earlier. A flexible system should allow travelers to choose her/his way for prioritizing the alternative solutions.

In addition to the future work, we have started to build a path-planning algorithm based on uninformed-search algorithms[3]. However, these algorithms might not provide satisfactory performance for ordinary shortest-path applications when the network is large. Nevertheless, these algorithms might provide satisfactory performance for constrained shortest-path applications in a median-sized city like the one we are tackling. Considering the fact that uninformed-search algorithms are far easier to construct than the informed-search algorithms, uninformed-search algorithms might be a viable way to the bus scheduling problems. We will report findings of our exploration in an extended version of this paper.



(a) (b) (c) (d)

Figure 3: Examples of original/destination Integrated Route Information

References

[1] Bordewijk, J.L. & Van Kaam, B. Towards a new classification of Tele-Information services, *Intermedia*, 14(1), 1986.

[2] N. Koga. Public transportation priority system using optical bus detectors. In *Proceedings of the IEEE/IEEJ/JSAI International Conference on Intelligent Transportation Systems*, pp. 135-138, Tokyo, Japan, 1999.

[3] S. Russell and P. Norvig. *Artificial Intelligence: A Modern Approach*. Prentice Hall, 1995.

[4] 交通部運輸研究所智慧型運輸系統網站，*台灣地區發展智慧型運輸系統綱要計劃*。<http://www.iot.gov.tw/its/HTML/MasterFinal/P_IDX1.HTM>

[5] 台北市政府交通局指導發行，*縱橫台北—北市大眾運輸系統搭乘指南*，November 1998.

[6] Bureau of Transportation of Taipei city government, http://www.busline.tcg.gov.tw (accessed on May 2000)

[7] Taipei City Bus Adminstration, http://tcba.tcg.gov.tw (accessed on May 2000)

[8] Taipei Rapid Transit Corporation, http://www.trtc.com.tw (accessed on May 2000)

[9] Taiwan High Speed Rail Corporation, http://www.thsrc.com.tw (accessed on May 2000)

[10] Taiwan Railway Administration, http://www.r ailway.go v.tw (accessed on May 2000)

Analyses of Cognitive Effects of Collaborative Learning Processes on Students' Computer Programming

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The purpose of this study was to clarify the cognitive effects of collaborative learning on Junior high school students' Logo programming. Two experiments were implemented: *Experiment1* was an analysis of the relationships between interaction in pair activities and students' reflection. The effects of pair learning on students' promoting abilities of programming were analyzed in *Experiment2*. As the results of *Experiment1*, students' self-monitoring and self-control were supplemented each other through the interaction. Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

Keywords: **Collaborative Learning, Junior High School Students, Cognitive Effects, Logo Programming**

1 Introduction

In Japan, education about computer programming was placed in *Fundamentals of Information* of *Industrial Arts* at junior high school level from 1989. From 2002, programming, sensing and control will be placed in *Information and Computer* of *Technology* as an elective learning content (*Course of Study* published in 1998)[5]. Many technology teachers in Japan thought that teaching programming was not only for professional higher education. They didn't made points of understanding the function of software upon a computer system, but acquiring the problem solving skills through the programming activities.

Historically, many researchers suggested that one of the methods for acquiring the problem solving skills was collaborative learning. It was necessary for students to communicate and interact with someone who had same goal in collaborative environment (Deutsch 1949)[1]. In the recent past, it was supported that the experiences of solving the problem through the interaction made the processes of planning and decision making clearly each other, and would promote their self-control and self-monitoring when they would solve another problem all by themselves (SATOU 1996)[3]. In the case of learning about programming, KAGE (1997) suggested that 12-year old pupils showed vigorous verbal interaction, which led them to more sophisticated problem solving [4].

From these findings, it was predicted that acquiring the problem solving skills brought to promote students' programming abilities as a result of cognitive effects of collaboration.

The purpose of this study was to clarify the cognitive effects of collaborative learning on students' programming. For this purpose, two experiments by using Logo programming (Japanese Edition) were implemented. The aim of *Experiment1* was to clarify the relationships between interaction of collaborative learning processes and learners' reflection. The effects of collaborative learning on students' promoting abilities of programming were analyzed in *Experiment2*.

2 Methods

2.1 Experiment1

2.1.1 Subjects

Twelve 3rd grader Jr. high school students (6 males and 6 females) were divided into 6 pairs.

2.1.2 Instruments

"The Reflection Scale of Thinking Process on Computer Programming: RSTC"(MORIYAMA et al 1996) [2] and the modified LUTE (Link-UniT-Element) model (MORIMOTO et al 1997) [6] were used for measuring the level of reflection and analyzing the interaction, respectively. The RSTC was constructed from 4 factors as in Fig.1. Factor1 was the reflection of understanding the problems and enterprising how to make the program adequately. Factor2 was the reflection of designing the program and coding. Factor3 was the reflection of self-monitoring on each parts of the program on the local level. Factor4 was the reflection of self-monitoring on the whole program and renewal of problem representation.

Factor1 (6 items)	**Factor2** (6 items)	**Factor3** (5 items)	**Factor4** (3 items)
Semantic understanding of the problem	Setting up the keywords	Predicting the result of running	Analyzing the bug
Imaging the command and grammar	Division of the program	Testing walk through the list	Renewal of problem representation
Comprehending the image of program	Setting up the functional unit	Checking the clerical error	Seeking the bug
Rhetorical understanding of the program	Connecting the functional unit	Checking the syntax error	
Seeking the semantically-related knowledge	Coding the functional unit	Checking the logical error	
Seeking the rhetorically-related skill	Checking the sequences of each commands		

Fig.1 The Reflection Scale of Thinking Process on Computer Programming: RSTC

The modified LUTE model was shown in Fig.2. There were categories for analyzing interaction of collaborative learning in this model, and this model had three abstract levels: element, unit and link level. The items of element level were categories for functions of protocols. The unit and link level categories were for phases and contexts in their programming activities.

Element Level (5 categories)	**Unit Level** (6 categories)	**Link Level** (6 categories)
Proposed	Phase of Analysis	Link for Formation of plan
Agreement	Phase of Plan	Link for Modification of plan
Question	Phase of operation	Link for Implementation of plan
Opposition	Phase of Edit	Link for Check of Implementation
Supplementary explanation	Phase of Checking the program list	Link for renewal of plan
	Phase of Checking the result of running	Link for renewal of implementation

Fig.2 The modified LUTE (Link-UniT-Element) model

2.1.3 Procedures

Subjects were asked to make the Logo program which draw the "*House*" constructed from triangular shapes, square patterns, circles and lines in pair. Their activities were recorded on a VTR. After they finished the task, they answered RSTC individually. Their protocols were extracted from the VTR and were categorized by using modified LUTE model. The level of reflection and the relative interaction in the collaborating pair were analyzed by ANOVA on mean scores of frequencies of link level categories and Coefficient of Correlation (r) between the RSTC scores and frequencies of the element and unit level categories.

2.2 Experiment2

2.2.1 Subjects

Sixty 3rd grader junior high school students (30 males and 30 females) were divided into 2 groups learning Logo programming. One was collaborative learning group (pair), and the other was individually learning group.

2.2.2 Instruments

The achievement tests and the RSTC were prepared. The achievement tests included both the coding test and the debug test. The coding test asked to make a program drawing "*Scarecrow*" on an answer sheet. The debug test asked to find three types of error, clerical error, syntax error, logical error from the program list which drew "*Spaceship*".

2.2.3 Procedures

The procedure was shown in Fig.3. At first, subjects had a coding test which draws the easy "*flag*" as a pre-test. Next, subjects were asked to make the program, which draws the "*House*" such as *Experiment1* and answered RSTC in every group as a middle-test. Finally, they had the achievement tests and answered RSTC individually as post-tests. The effects of collaborative learning on students' promoting abilities of programming were analyzed by using ANOVA and Coefficient of Correlation (r) between the RSTC scores and the Achievement tests' scores.

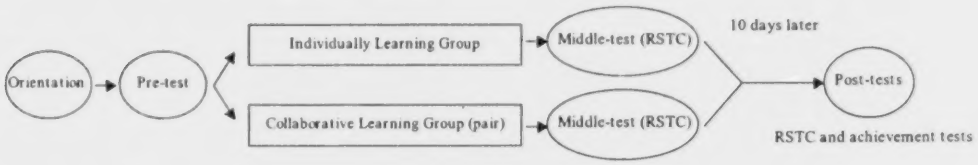

Fig.3 The procedure of *Experiment2*

3 Results and Discussion

3.1 Experiment1: Students' Reflections and Collaborative Programming

3.1.1 Contexts of Collaboration in the Pair Activities

There were differences of period of keyboard operation time in pair activities. In this analysis, long-operated learners were called *Learner A*, and the others (short-operated) were called *Learner B*. Mean scores of frequencies of link level categories were shown in Table.1.

Table.1 Frequencies of link level categories

Link Level Categories	Mean Score (S.D.)				ANOVA
	Learner A to B	*Learner B to A*	*Learner A to A*	*Learner B to B*	
Link for Formation of plan	1.75 (1.04)	2.00(1.77)	1.63(1.41)	3.50(2.73)	*n.s.*
Link for Modification of plan	3.35(2.12)	2.50(1.93)	0.25(0.46)	0.13(0.35)	F(3,24)=8.397, p<.01
Link for Implementation of plan	1.88(2.70)	15.63(5.80)	5.88(3.40)	2.75(2.49)	F(3,24)=21.732, p<.01
Link for Check of Implementation	3.75(1.49)	1.13(1.36)	1.00(1.07)	0.13(0.35)	F(3,24)=13.055, p<.01
Link for renewal of plan	0.38(0.52)	0.38(0.74)	0.13(0.35)	0.63(0.52)	*n.s.*
Link for renewal of implementation	0.63(0.92)	1.25(1.28)	0.25(0.46)	0.00(0.00)	*n.s.*

Results from Two-way Repeated Measures ANOVA showed that there were significant main effects of Links for Implementation of Plan from *Learner B* to *A* [F(3,24)=21.732, p<.01], and Links for Check of

Implementation from *A* to *B* [F(3,24)=13.055, p<.01]. Also, Links for Modification of Plan with interaction (*B* to *A* and *A* to *B*) were increased than that of individually links (*A* to *A* and *B* to *B*) [F(3,24)=8.397, p<.01]. These data indicated that the role of operation (*Learner A*) and the role of planning (*Learner B*) were shared in pair activities. However, it was suggested that consensus decision making through the interaction was important for building up their programming plans.

3.1.2 The Relationships between the Interactions and the Reflections

Coefficient of Correlation (r) between the RSTC scores and frequencies of element level categories were shown in Table.2. According to these data, when *Learner A* (operator) proposed something to operate, the reflection of designing the program (Factor2) was promoted in own thinking process [r=0.88, p<.01]. However, when *Learner B* (planner) proposed, the reflection of self-monitoring on each parts of the program (Factor3) was promoted in *Learner A*'s thinking process[r=0.88, p<.01]. Furthermore, opposition by *Learner A* correlated the reflection of self-monitoring (Factor3) in *Learner B*'s[r=0.71, p<.05]. Also, *Learner A*'s reflection of designing (Factor2) was promoted by the opposition of *Learner B*[r=0.77, p<.05]. These results indicated that the verbal communications on their interaction brought out their self-monitoring and self-control each other.

Table.2 Coefficient of Correlation (r) between the RSTC scores and frequencies of element level categories

Element Level Categories		Factor1		Factor2		Factor3		Factor4	
		Learner A	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*	*Learner A*	*Learner B*
Proposed	*Learner A*	0.41	0.26	0.88**	0.41	0.52	0.13	0.06	0.06
	Learner B	0.04	0.45	0.37	0.25	0.88**	-0.33	0.50	0.31
Agreement	*Learner A*	0.00	-0.10	0.31	-0.34	0.52	-0.66	0.26	-0.20
	Learner B	0.44	0.35	0.67	0.55	0.28	0.08	0.36	0.07
Question	*Learner A*	-0.32	0.56	0.27	0.28	0.56	-0.11	0.78*	0.23
	Learner B	0.40	-0.52	0.56	-0.29	0.00	0.02	0.03	-0.31
Opposition	*Learner A*	0.03	-0.30	0.27	0.08	0.13	0.71*	0.42	0.19
	Learner B	0.12	0.19	0.77*	0.23	0.52	0.27	0.68	0.00
Supplementary explanation	*Learner A*	0.72*	-0.35	0.61	0.13	0.03	0.40	-0.15	-0.01
	Learner B	-0.01	-0.34	0.32	-0.13	0.14	0.40	0.45	0.08

n=8, df=6, **p<.01, *p<.05

In addition, Coefficient of Correlation (r) between the RSTC scores and frequencies of unit level categories showed that, operation by *Learner B* as a planner conduced to *Learner A*'s self-monitoring on whole program[r=0.85, p<.01]. Also, task analysis by *Learner A* as an operator encouraged *Learner B*'s designing of the program[r=0.75, p<.05]. It was evident that one's reflective thinking was precipitated by the observation of the other's behavior which was supposed to be his own behavior.

These results of *Experiment1* suggested that students' meta-cognition (self-monitoring and self-control) were supplemented each other through the interaction of collaborative pair learning.

3.2 Experiment2: Effects on students' promoting abilities of programming

3.2.1 Acquisitions of Programming Abilities

In the pre-test, there are not significant differences between the pair learning group and the individually learning group [F(1,56)=0.65, *n.s.*]. Students who could get high scores were called *higher students* and the others were called *lower students* in this analysis (both 50% and n=30). In the middle-test, mean score of RSTC in the pair learning group (0.77) was higher than that in the individually learning group (0.56) [F(1,56)=32.40, p<.01]. This result supported findings of *Experiment1* because collaborative pair learning could promote students' reflections of thinking processes.

Mean scores of debug test were shown in Fig.4. Results from the ANOVA showed that the debugging scores of syntax error in the pair learning group was higher than that in the individually learning group [F(1,56)=4.75, p<.05]. But, there were not significant differences on the debugging scores of clerical and logical errors [F(1,56)=2.06 and F(1,56)=0.89, both *n.s.*]. These results indicated that collaborative pair learning could form students' debugging abilities against syntax errors, at least.

Mean scores of coding test were shown in Fig.5. The result from the Two-way Repeated Measures of ANOVA showed that there was significant interaction between *High-Low student* condition and *pair-individually* group condition [F(1,56)=10.46, p<.01]. Furthermore, from the results of Simple Main Effects Tests, the score of *lower students* in the pair learning group was promoted to the same level as *higher students* in both groups [F(1,56)=12.56, p<.01]. These results indicated that the coding abilities of Low-Ability students could be pulled up through the interaction with High-Ability students.

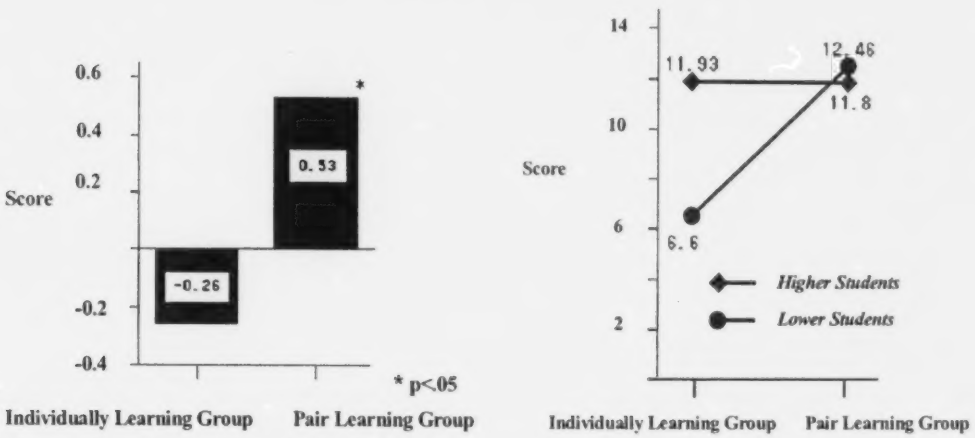

Fig.4 Mean scores of debug test (syntax error)

3.2.2 Acquisitions of Cognitive Strategies

Coefficient of Correlation (r) between the RSTC scores and the achievement tests were shown in Table3. According to these data, there were significant correlation between the coding test and the RSTC items: "Division of the program"(r=0.31, p<.05), "Coding the functional unit"(r=0.41, p<.01), "Connecting the functional units"(r=0.40, p<.01) and "Selecting the commands for each functional units"(r=0.40, p<.01) . Also, There were significant correlation between the debug test and the RSTC items: "Division of the program"(r=0.29, p<.05), "Checking the sequences of each commands"(r=0.33, p<.01). It was indicated that promoting these reflections were responsible for the development of the programming abilities. Furthermore, these items suggested the reflections of cognitive strategies for task division.

Table 3 Coefficient of Correlation (r) between the RSTC scores and the achievement tests

Items of RSTC	Achievement Tests			
	Coding Test		Debug Test	
Division of the program	0.31	*	0.29	*
Coding the functional unit	0.41	**		
Connecting the functional units	0.40	**		
Selecting the commands for each functional units	0.40	**		
Checking the sequences of each commands			0.33	**

**p<.01, *p<.05

Results of *Experiment2* suggested that the effect of collaborative learning on students' programming abilities were developments of debugging ability against syntax error and coding ability of lower students, which was obtained the cognitive strategies for task division through the interaction.

4 Conclusion

In this study, it was clarified that students' meta-cognition and cognitive strategies could be acquired through the collaborative learning at junior high school level, also that the RSTC was useful for measuring students'

reflections in their programming activities. These findings will contribute to the researches of developments of collaborative learning systems.

For the future, learning processes and cognitive effects of more widely collaborative learning environment, for example, distributed programming by using CSCL system or long distance education for programming by using Internet, must be analyzed.

References

[1] Deutsch, M, An experimental study of the effects of cooperation and competition upon group process, *Human Relation*, 2: pp.199-232, (1949)

[2] Jun MORIYAMA et al, Structural Analysis of Thinking Processes on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 38-4: pp.255-262, (1996) (In Japanese)

[3] Kouji SATOU, Motivation for Learning and social context, *Cognitive Science 5: Learning and Development*, Tokyo University Press: pp.221-247, (1996) (In Japanese)

[4] Masaharu KAGE et al, Effects of Media and Learner Collaboration on Programming Education in Children, *Japan Journal of Educational Technology* 21-2: pp.93-105, (1997) (In Japanese)

[5] Ministry of Education, Science, Sports and Culture, Government of Japan, *Course of study for lower secondary schools in Japan*,(1989) (In Japanese)

[6] Shiro MORIMOTO et al, An analysis of Collaborative Discovery Learning Processes Based on Hierarchical Schema, *Cognitive Science* 4-2: pp.3-17, (1997) (In Japanese)

Note:

This study was revised and enlarged version of the following papers published in Japan:

Jun MORIYAMA, An Analysis of Collaborative Learning Process on Students' Computer Programming, *Journal of Japanese Society of Technology Education*, 41-4: pp.187-196, (1999) (In Japanese)

Jun MORIYAMA et al, Development of the students' abilities for Computer Programming through the Collaborative Learning, *Proceedings of the 42nd Annual Conference of Japanese Society of Technology Education*: p.21, (1999) (In Japanese)

Design and Implementation of A N-Tiered Heterogeneous Virtual School Administration System

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There are two types virtual school administration systems, web-based or voice-based, which are currently used by students. They are systems with different access mechanisms but same business logic, and require two times of resources for development and maintenance. Whenever the business logic of the systems changes, both of the systems need to be implemented. As the wireless communication grows more popular, the school has been considering adding a wireless interface to the system. However, with current architecture, the only way to add a wireless application protocol (WAP)-based system is to implement an additional system from scratch. Since the voice-based system and the web-based system have the same business logic, they can be integrated into one. We can dedicate an application server for the business logic, which interacts with the web-based interface and the voice-activated interface with a set of application programming interface (API). With the extraction of the business logic and the business logic API, developers for the voice-activated interface and the web-based interface can implement the interfaces without specific knowledge of the business logic of the system. With this design and architecture, the system can be further expanded to support a WAP-based interface and other interfaces easily.

Keywords: **Internet, wireless, virtual school, heterogeneous**

1 Introduction

The Internet is widely used for school education, especially virtual school education [2][3][4]. The advantage of the Internet is its capability of supporting multimedia and its attractiveness to the user. For the virtual school education, the students study via the Internet. They do not have to be in the classrooms of a school and can learn at anywhere at anytime. However computers and communication networks are needed to support virtual education through the Internet. The cost of the computers and setting up the communication networks is very expensive. Thus, the systems are not available everywhere. Furthermore, system interfaces must be developed in order to allow the users to access the computers and the networks. The purpose of these system interfaces is to provide an easier way for the students to access the systems and to allow the students to interact with the instructors real-time. Those systems interface do not need to be attractive and colorful since its main goal is to provide a mechanism for the students to access information real-time. For a web-based system, the homepage can be design in a way to reduce the network traffic and system load. However, not every student can access the computers and the networks due to his financial situation or the load of the system. For the students who cannot access the computers and the networks, the telephone (the voice activated based interface) provides another popular access media. Therefore there are needs for systems to support both telephone (voice- based) and web browser (web-based) interfaces [1]. The web-based system is more visual and more user friendly, however, the voice-based system is more convenient, more affordable, and requires no hardware investment from the students. As the technology evolves, the wireless communication is gradually taking over the traditional wire line communication. To support the wireless communication the system will need to be expanded to support the wireless application protocol (WAP)-based interface [10].

Originally, a couple of the school administration systems we had can be accessed via a regular telephone or via a web browser but not both. They were basically two different systems, though they support the same business logic. Both of them have their own user interface and system logic and were designed, implemented, and maintained separately. To support them two sets of resources are needed. The original system architecture is shown in Figure 1. Developers for both of the systems handle both the business logic's and the user interface's design and implementation. Whenever the business rule changes, both of the systems need to be modified and updated. It is very costly and difficult to keep both of the system consistent.

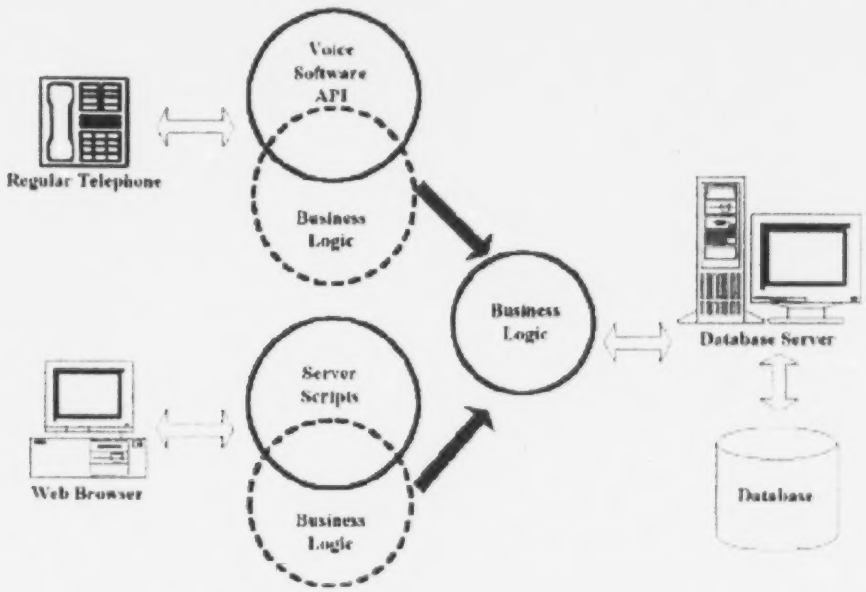

Figure 1. Logic view of voice system and web system

To reduce the maintenance cost of the two systems and to make them easier to be upgraded and expanded, we have proposed to integrate the two systems by extracting the business logic module out of them and migrate it into an application server. The remaining of the systems is migrated into a web server and a voice server respectively. By doing this, we dramatically reduced the cost of maintaining the system. After the architecture change, whenever there is a business change, only the application server is affected. We reduced the maintenance cost by 50%. No more concerns about the consistency of the systems. With the modification of the system architecture, we make it more scalable and expandable. The system can be easily expanded to support other access media without making changes to the application server. For example, to support a WAP-based interface, a WAP server can be easily introduced and integrated into the modified system architecture.

2 System Architecture and Implementation

2.1 Architecture

The administration system is an N-tiered system.

- Data Services Tier: The database services and implementations.
- Business Logic Tier: The business rule of the system.
- Translation Tier: Translate the I/O between application server and gateway server. For the voice-based system, the gateway server is the voice server. The purpose of the voice server is to translate PSTN and HTTP between application server and usual telephone. For the web-based system, the translation tier is transparent; it does not do anything. For the WAP-based system, the WAP Gateway is the gateway server. The purpose of WAP Gateway is to translate the WSP/WTP and HTTP between WAP telephone and web server.

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- Presentation (UI) Tier: The input and output of the web-based system is HTML. The input and output of the voice system is the key press and voice of usual telephone. The input and output of the WAP-based system is WML [10].

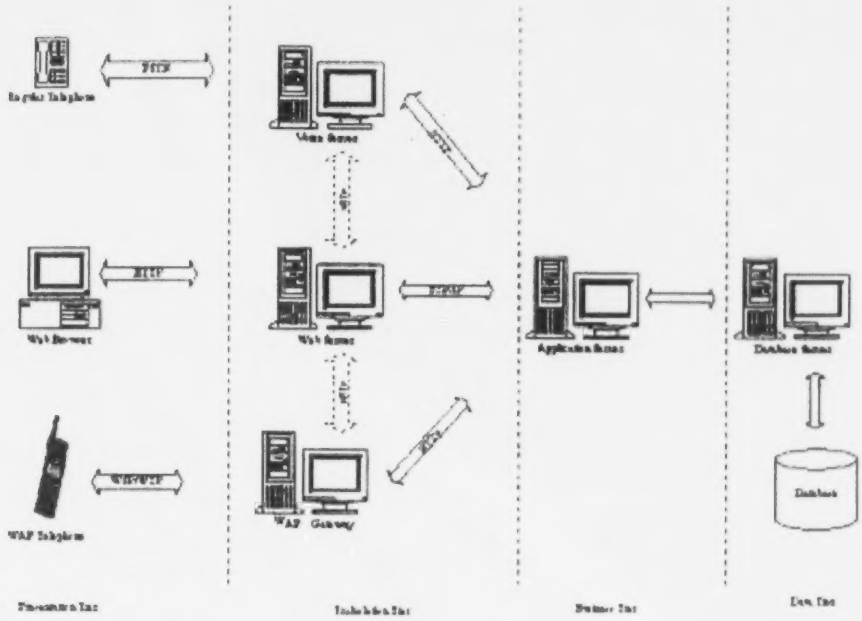

Figure 2. System Architecture

In the Architecture, the application server is the most important part. The application server needs to process business logic and interact with voice server, web server, and WAP Gateway. Because the protocol between the application server and the voice server and the WAP Gateway is HTTP protocol, we can set the application server and the web server in the same machine. The developers of the application server are more responsible, because they must handle business rule, HTML and WML. The developers of the other systems implement User Interface and do not have the knowledge of business rule of the system, because the developers of the application server handle the business rule. The application server sends different output format to different systems by parameters. Under the Architecture, after building the web system, the other systems are easily to build.

2.2 Architecture of the Voice System

Because taking business logic out of the voice system, the function of voice system is coherent. It translates the output of web server to telephone. The output format of web server is HTML. So the voice server has to simulate to web browser, shown as in Figure 3.

Figure 3. The communication methods are between voice server and web server.

3 Case Study

The Enrollment System of the Tamkang University [7] is designed and implemented following the architecture of this paper, shown as in figure 4. The system has been deployed and used by thousands of concurrent users [8].

3.1 Hardware Structure

We used thirteen Pentium based servers to implement the system. Six of them are used as the web servers. One machine is used as the UNIX Gateway. One server is used as the alert and automating email server. Four voice servers are used to support the voice activation. Finally, all student enrolment information is stored in one database server. The network hardware are two 100 MB/sec switch hub.

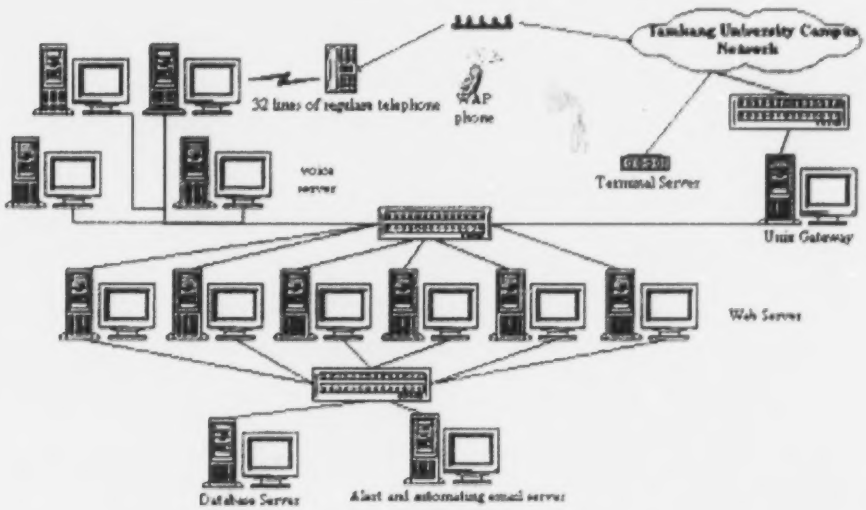

Figure 4. System Hardware Structure

3.2 System Software

OS: Microsoft NT4.0 is used for the web servers, voice servers, and the alert and automating email server. Free BSD 3.0 is used for the UNIX Gateway [8].
Web server: Microsoft IIS 4.0.
Database: Microsoft SQL Server 6.5.

3.3 Load Balancing and Scalability

To make the system suitable for all schools, we also took into considerations of the cost of hardware and the scalability of the system. A set of low-end servers can be grouped together to replace a high-end server[6]. To achieve this, a DNS server is needed for the load balancing work. The simple round robin methodology is used for the load balancing. With the current flexible four-tiered architecture, servers can be added into the system to share the performance load whenever the system load is heavy[9].

3.4. Security

Two security strategies are used to increase security:

1. Packet filter: It only allows IP packets through port 80 to access the web server, the packets of the other ports can not pass through. The web system can avoid being attacked by the other machines.
2. Supports multi-protocol: TCP/IP protocol is used between the web server and outside systems. IPX protocol is used between the web server and the database server. The web server should be hacked, the database server is kept away Internet and the database is still safe.

3.5. Network Management and Monitoring

The alert system has the following features:

1. Monitoring the system: It sends to keep-alive message to web servers, voice servers, and database servers in every period.
2. Network management system: Checks network traffic between web servers, voice servers and database server.
3. Auto Backup the data of database server.

3.6. User Interface Design

One of the most important criteria of the virtual school administration system is to let students access and retrieve correct information real-time. The user interface must be simple to reduce network traffic and system download time. The homepages for the web system and WAP are simple and straightforward to improve system performance. The look and feel of the WAP homepage depends on the WAP telephone the user users. An Ericsson r320 model WAP homepage is shown here as a sample WAP homepage. We can compare the home pages for the web system and WAP system.

Figure 5. The display of the homepage of WAP-based system

3.7 Log statistics and analysis

Duration of enrollment period, the system generates the log automatically everyday for statistics and analysis, as shown in Table 1.

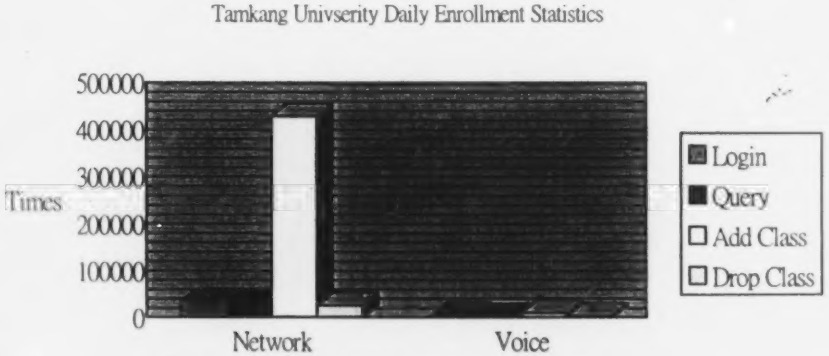

Table 1. Tamkang University Daily Enrollment Statistics

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By comparison, the load of the web system is much heavier than the load of voice system. Since the voice system has 32 telephone lines, it can only support 32 concurrent users. In the peak hour of the enrollment (the first hour of each grade enrollment), the load of the web server is high.

We expect the voice system and the WAP system to be fully loaded during the peak hour. A dedicated business logic-processing server is used for the voice system and the WAP system. Since the telephone lines of the voice system and the WAP system are limited (up to 32 lines), a dedicated web server for the business logic processing of the voice system and the WAP system is sufficient.

4 Conclusions and future development

The development and maintenance resource of the heterogeneous systems depends on how many access media. The more access media, the more resource it needs. My proposal has the following advantages:

- Resource Reducing: Because the business logic is centered, heterogeneous systems need one business-logic process only, the resource of development and maintenance is less than usual systems.
- Expandability: With the N-tiered system architecture design, the business logic system was designed and implemented to support different UI systems. Different UI access method can be easily added into the system.

In the system, the application server interacts with voice server and WAP Gateway on HTTP protocol., so the application server must have functions of the web server. We can develop a new structure of the application server for voice-based system and WAP-based system, and the application server interacts with the voice server and WAP Gateway on TCP/IP.

References

[1] C. Chou and C. T. Sun, "A Computer Network-Supported Cooperative Distance Learning System for Professional Communication Education", IEEE Transactions on Professional Communication, Vol. 39, No. 4, pp. 205-214, (1996).

[2] Colin McCormack & David Jones, "Building a Web-Based Education system", John Wiley & Sons, (1998).

[3] Dwyer, D., Barbieri, K.& Doerr, H. M., "Creating virtual classroom for interactive education on the Web", Computer Networks and ISDN Systems 27, pp. 897-904, (1995).

[4] Nian-Shing Chen, "Web-based Learning Environment", Information and Education, Vol. 64, April, pp. 2-13, (1998).

[5] C. T. Sun, C. Chou & B.K. Lin, "Structural and Navigational Analysis of Hypermedia Courseware", IEEE Transactions on Education, Vol. 41, No. 4, CD-ROM, November, (1998).

[6] Chen-Chung Liu, Gwo-Dong Chen, Kuo-Liang Ou, Baw-Jhiune Liu & Jorng-Tzong Horng, "Managing Activity Dynamics of Web Based Collaborative Applications", International Journal of Artificial Intelligence Tools, Vol. 8, No. 2, (1999).

[7] Gooshyon Hwang & Chao-Tsong Fangtsou, "Introduction of Tamkang University Enrollment System", Ministry of Education Computer Center Newsletter, Vol.8802, (1999)

[8] Jack Chou, "NT Dynamic Web Server Design", Unalis Company, (1997)

[9] J.J.P. Tsai, S.J. Yang & A. Liu, "An Integrated Architecture for Distributed Real-Time Systems Analysis", in IEEE Second World Conference on Integrated Design and Process Technology, Austin TX., pp. 152-159, (1996) Dec. 1996

[10] WAP Forum, http://www.wapforum.org/what/whitepapers.htm (accessed on July 1, 2000)

Design and Implementation of a WWW - Based School Official Memorandum System

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1 Introduction

The official memorandum is a very important document that offers a decision path of something in the most organizations. In general, the executed policy usually needs agreement of decision-maker through official memorandum. All the official memorandums are traditionally passed by one-by-one human delivery from faculties to managers in an organization. It may results in the lower performance of administrative. Even though some administrative operations are via e-mail or other approach. It have some limitations, such as the official documents usually need the signature of decision-maker, it is not ease to overcome via the e-mail.

In order to have a speedy the administrative operation environment, especially the official memorandum delivery, we design and implement a WWW-based Official Memorandum System in a school. That is a WWW application without any novel theory and technique. We apply the existing techniques used in the WWW environment to accomplish the application.

Obviously, the system is based on the client-server model. Implementing the system has some existing techniques can be used, such as CGI, Java/Servlet [3], Java/CORBA [3]. Lotus' InterNotes [1] product uses CGI mechanisms to allow Web browser access to documents and forms managed by the Notes Server. Documents to be placed on the Web are translated by a program to HTML. These documents and forms are accessed through a standard HTTP server as though they were normal HTML documents. Java is a portable object-oriented language, and also a good platform for writing client/server web-based applications. Servlets are secure protocol and platform-independent server side web-enabled software components, written in Java. Java/CORBA has a clear advantage over CGI solution, such as flexibility, maintainability, and responsiveness etc.

Security issue in the system will be taken care by using traditional approaches. There are two secure mechanisms will be used: one is account/password, the other is the firewall. First one can prevent non-authority user log-in into system and disrupt the system. All the general users must apply for an account excepting the chief of depart. ent. And the system will force all users to change the password periodically. This mechanism can avoid in. rnal hackers. Second one is to avoid external hackers who intrude into system for non-authority accessing. Few hackers, of course, can intrude into and disrupt the system. Some approaches can be used for enhancing the security of information, such as data compression/decompression before accessing to/from database and checking the data consistency of duplicated database periodically. All of them are the future works

Fault tolerance is in order to enhance the reliability of system. In fault-tolerance community, many approaches have been proposed to enhance the data reliability [4,5]. The approach in the system is database replication. We use warm stand-by primary/backup scheme to improve the system availability. Many issues in the data replication that have to be guaranteed are employed like the [5]. These issues are such as idempotent operation, data consistency, and recovery. Because the system is a three-tier scheme, all operations supporting fault-tolerance are implemented in the core of the system. This feature can also prevent the database crash during the formal exe cution phase.

A complex system has to be manageable in an easy way. In order to enhance the system flexibility, a web-based management tools should be implemented. System manager can add and remove user easily. In

addition, system manager can also maintain the database, such as record manipulation, in an easy way.

Many features are described previously. In addition, we will support some important functions shown as following: Official documents writing, Official documents progression tracking, Auto-delivery, Automatic signing, Urgent document notification.

2 Design and Implementation

According to the described above, we design the system architecture like as Figure 1. The architecture is simple and complete. The system includes an Official Memorandum System and a replicate l database. The system will receive requests from clients. For security issue, we add a firewall in the front of web server. All the requests must be checked by the firewall for ensuring the request is an authority request. In addition, the Official Memorandum System is responsible for all the features described above, which include fault-tolerance. A replicated database is also included in the system. The database used in the system is the SQL database.

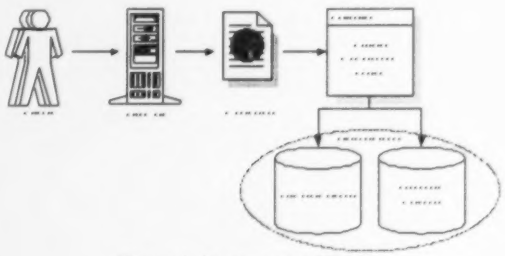

Figure 1. System Architecture

The whole system is implemented and run on the Windows NT 4.0 and SQL server 7.0. The programming paradigm is ASP that using VBscript. With the fault-tolerant, the system needs to access primary and standby database separately. To guarantee the consistency of two databases, we apply the traditional two-phase commit protocol on the replicated database transaction processing.

Figure 2 shows the GUI of document reviewing for those chiefs of department. When they login into the system, the system will show the urgent document on top of the reviewing page, which indicate these documents have to review first. The document reviewing process will sign the signature automatically when the process achieved.

Figure 3. The GUI of Document Reviewing

3 Conclusions

In this paper, we have been stated the design and implementation of a web-based official memorandum system. This system can migrate the conventional official memorandum system to network. That is a WWW application without any novel theory and technique. We apply the existing techniques used in the WWW environment to accomplish the application. In order to avoid the informal accessing to this system, the firewall is utilized at the front-end of the system. Besides, the duplicated databases are used in this system to prevent the database crash during the formal execution phase.

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References

[1] Lotus Development Corp., "Lotus InterNotes Web Publisher", Setember 1995, http://www.lotus.com/corpcomm/334a.htm.

[2] Evans and D. Rogers, "Using Java Applets and CORBA for Multi-Users Distributed Applications", IEEE Internet Computing, Vol. 1, May-June 1997, pp.43-55.

[3] Guang-Way Sheu, Yue-Shan Chang, Deron Liang, Shyan-Ming Yuan, Wintson Lo, "A Fault-Tolerant object service on CORBA" in Proc. of the 17th International Conference on Distributed Computer Systems (ICDCS'97) Baltimore, USA, pp.393-400.

[4] Yue-Shan Chang, Jyh-Tzong Chiou, Shang-Rong Tsai, "Highly Reliable File Services on the DMINIX System, " The 11th Technological and Vocational Education Conference of R.O.C., Vol.3, Mar. 1996, pp. 30-39.

DIYexamer: A Web-based Multi-Server Testing System with Dynamic Test Item Acquisition and Discriminability Assessment

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With the rapid growth of both computer technology and the Internet, conventional models of testing are gradually being replaced by CAT (Computer Assisted Testing) systems. However, the major problem in most CAT systems is the difficulty in refreshing and supplying test items. This paper presents a novel network CAT system, DIYexamer (Do-It-Yourself Examer). It has three features that differentiate it from existing CAT systems: student DIY items, item-bank sharing, and automatic assessment of item discriminability. DIYexamer accepts test items contributed form teachers as well as students, and allows limited item sharing between item-banks possibly maintained by different organizations. An algorithm is applied dynamically to assess the discriminability of items in item-banks in order to filter out less qualified contributions, hereby assuring the quality of stored items while scaling up the size of item-banks.

Keywords: **computer assisted testing, test evaluation, test acquisition, discriminability, distant learning**

1 Intorduction

With the continuing development of computer technology and the Internet, educators now have new alternatives for creating, storing, accessing, distributing and sharing learning as well as testing materials. Should testing be performed on or learned from computers, and then a computer can best assess the work, Bugbee (1996)[1]. Hence, assessing the learning achievements and attitudes of students via computers or networks becomes a challenging task for many educators and researchers.

A. Computer-assisted Testing Categories

Computer-assisted Testing (CAT) or Computer-based Testing (CBT), the use of computers for testing purposes, has a history spanning more than twenty years. The documented advantages of computer administered testing include reductions of testing time, an increase in test security, provision of instant scoring, and an individualized adaptive testing environment [2][3][4][5]. As listed in Table 1, three categories of CAT are currently employed: standalone packages, test centers and networked systems.

TABLE 1: Categories of CAT

	Network support	Item generator	Random item selection	Item source	Item quality assessment	Item-bank sharing	Test result analysis
Standalone package	No	Built in item-bank	Yes	Fixed	No	No	Yes
Test center	Yes	Expert	Yes	Limited	Yes	No	Yes
Networked system	Yes	Built in item-bank	Yes	Fixed	No	No	Yes

1) Standalone package: This type of computer software package is typically stored on disks or CD-ROMs. Some packages have built-in item-banks, while others require teachers to input test items. These CAT packages generally do not have network capabilities.
2) Test center: The test centers or lab services require dedicated computer terminals for testing purposes. Students are required to complete the computer-based tests at the centers. Well-known applications of this type of service are Graduate Record Examinations (GRE) and Graduate Management Admission Test (GMAT), as provided by Educational Testing Services (ETS) [6].
3) Networked system: This enables students to perform an examination through an Internet connection. Concurrent testing of multiple users, automatic score calculation, and automatic test result analysis are supported by a networked system. The major advantages of networked systems are the convenience of examinations and test result calculation. However, the major flaws are the limitation of the amount of items and no item discriminability assessment.

B. Problem Statement

Regardless of which CAT system is employed, a critical issue in developing CAT is the construction of a test item-bank. Traditionally, asking teachers and content experts to submit items generates the item-bank. Three major drawbacks of the traditional method can be observed:
1) Limitation of item amount: Teachers and content experts tend to have similar views on the test subject. That is, in a given field vital subject matter might be confined. Therefore, although more teachers and content experts are invited to contribute test items, the total number of distinct items remains low.
2) Passive learning attitude: Students are conventionally excluded from the creation of tests. In a typical computer-assisted testing system, teachers generate tests, the system prescribes test sheets and students then complete the tests. That is, within the system of testing, they play a passive role, and are not afforded the opportunity to conduct "meta-learning" or "meta-analysis."
3) No guarantee on item quality: Permitting students to generate tests may be a possible solution to the aforementioned problems. However, this raises a new problem: quality assurance and ensuring that the tests are worth storing and used for further tests. Even when the whole item-bank is contributed by teachers and content experts, ways to dynamically assess and filter test items are needed.

The rest of this paper is organized as follows. The three distinct features of DIYexamer are introduced in section 2. Section 3 describes how the DIYexamer was implemented and its functionalities for administrators, teachers, and students. The discriminability calculation formula is then presented in section 4. Finally, the accuracy of discriminability discretion of DIYexamer and conventional methodology are compared through a real-life test in section 5.

2 The Diyexamer Solution

The DIYexamer[7] is a Web-based multi-server system that allows students to contribute test items, and provides an effective means of verifying the discriminability of these items. Three main ideas are as below:

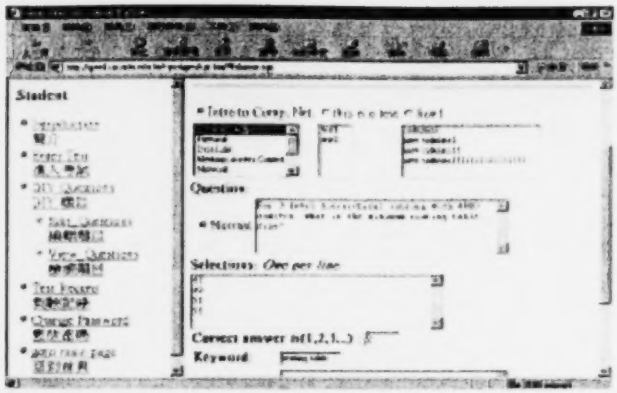

Fig 1: Students generate items into the item-bank

1) Item DIY by students: DIYexamer allows students to generate test items into the item-banks online as Fig 1. Teachers can query these items generated by students as Fig 2. In addition to rapidly increasing the total number of items in an item-bank, this feature also encourages students to develop *meta-learning*, i.e. *creative learning*. In order to submit tests, students must thoroughly study the learning materials, develop higher-level overviews of the materials, and practice cognitive and creative thinking.

Fig 2: Student DIY items as queried by teachers

Fig 3: Average item discriminabilities of item-banks

2) Assessment of item discriminability: DIYexamer provides an item-discriminability assessment method to ensure the quality of the stored items. In addition to ensuring the internal consistency of existing test items, this method also continuously and dynamically screens additional new items in the item-bank. Fig 3 shows the average item discriminabilities of several item-banks.
3) Item-bank sharing: DIYexamer, a scalable multi-server system, connects many item-banks stored in different servers. Therefore, via the Internet, more items can be accessed and shared. The sharing is limited and controlled in a sense that a server issues a request, describing the criteria of a test item it requests, to another server. A server does not open up its item-bank for unlimited access.

Additional advantages have been identified and include the facts that since DIYexamer provides a real-time on-demand generation of test-sheet function, cheating is avoided. Also, DIYexamer provides an item cross-analysis function to which the degree of difficulty for each test as well as the entire test base can be accurately measured.

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3 Diyexamer System Implementation

A. DIYexamer Network Architecture

DIYexamer is a WBT (WWW-Based Testing) system. An important feature is the sharing of item-bank via network connections. According to Fig 4, several DIYexamer servers form a *scalable test union*. Therefore, each server can access other servers and thus achieve item-bank sharing. A remote server can also join the test union to share additional test-bank resources, and leave the test union without affecting other servers.

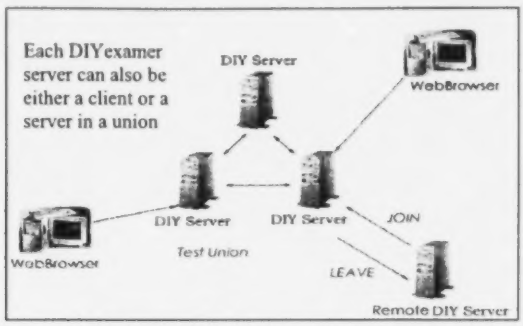

Fig 4: Network Structure of DIYexamer

B. Internal System Model

The internal architecture of DIYexamer (Fig 5) is divided into three layers. Interface layer is responsible for providing web interface for users. Test Profile Layer (TPL) selects items to form a test sheet, computes scores, and calculates the discriminability of selected test items. Test base Sharing Layer (TSL) accesses both local and remote databases via a network. Three functions of TSL are listed in Table 2:

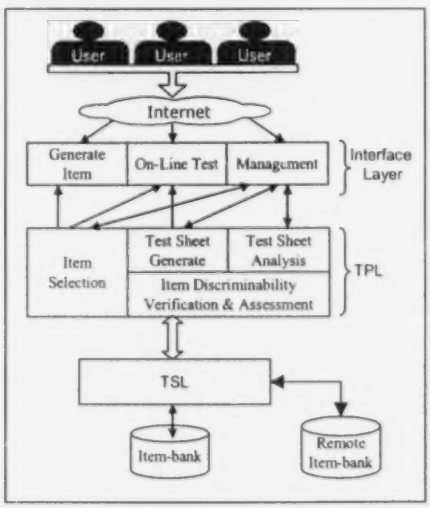

Fig 5: Structure of DIYexamer

TABLE 2: Functions of TSL

Function	Description
Add new items	New items and corresponding answers are categorized to specific chapters and stored in the local item-bank.
Access local item-bank	Accessing local while generating test sheets and calculating discriminability.
Connect to remote item-bank	Item-bank sharing through a connection to a remote item-bank.

Environments and development tools used to construct DIYexamer are listed in Table 3. Perl is used to write CGI programs to create user interface as homepage. Apache, an open source web server software, is responsible for front-end. The back-end, item-bank, is handled by Postgres.

TABLE 3: Environments and development tools

Function	Tools
HTTP Server	Apache 1.3.3 [8]
Programming Tools	Perl 5.003 [9]、CGI.pm-2.56 [10]、Gd.pn-1.14[11]
DBMS	Postgresql 6.5.3 [12]
O.S.	Red Hat Linux release 6.1[13]

C. Functionalities for administrators, teachers and students

DIYexamer provides a web interface for users to remotely control and operate the system. Three types of users are supported: administrators, teachers, and students. Corresponding functionalities are listed in Table 4.

TABLE 4: Functionalities for different users

	Administrator	Teacher	Student
System and Database	• Examine system status • Join a test union • Leave a test union • Create personal accounts • Create group accounts • Modify accounts • Modify item-bank • Redact course division • Backup database	• React course division	
Item production		• Create tests sheet • Select test items • Edit test items • Read test items	• Edit test items • Read test items
Test	• Network Invigilate	• Input scores of homework	• On-line test
Analysis	• Analyze tests • Analyze test items	• Analyze tests • Analyze test items • Analyze subjects and divisions	• Analyze tests
Inquiry		• Inquire tests • Inquire test items generated by students • Inquire students scores	• Inquire personal scores

4 Discriminability Assessment Of Diyexamer

A. Method of Traditional Discriminability Assessment

A criterion against which the quality of test items is judged is the assessment of discriminability. An item is regarded as with high discriminability when competent students correctly answered it, while less competent students incorrectly answered it, and vice versa. When computing item discriminability, those students with relatively high and relatively low scores are taken as samples. Those students whose scores fall in middle range not

considered. Next, item discriminability is computed according to the performance of these sampled students when answering each item.

In the traditional discriminability assessment method[14], those in the top 30% and the bottom 30% rank groups are chosen as samples. The top 30% scorers are defined as "high-rank group (H)", while the bottom 30% scorers are defined as "low-rank group (L)". The formula for calculating the discriminability of an item is as follows:

$$\text{Discriminability} = \frac{\text{The number of students in H that answered correctly}}{\text{The number of students in H}} - \frac{\text{The number of students in L that answered correctly}}{\text{The number of students in L}}$$

In the traditional method, two major drawbacks can be observed. The first one has something to do with whether the 30% is in terms of *count of students* or *range of scores*. The sampled students fall in the top 30% and the bottom 30% rank groups, i.e. in terms of *counts*. However, it is possible that these scores differ only slightly from the average score especially when scores are not wide-spread distributed, where many scorers should not be considered in computing the discriminability. Second, the effect on discriminability assessment by each student in either group is assumed to be the same. However, those students that received different scores have different degrees of tendency to correctly or incorrectly answer an item. For example, a sampled student who received 97 points should have higher referential value than a sampled student who received 80 points.

B. Method for DIYexamer's Discriminability Assessment

When selecting sample students, only those whose scores have large gap with the average score should be considered. Accordingly, those with the top 30%, in terms of range, scores are defined as "high-score group (H')", while those with the bottom 30% scores are defined as "low-score group (L')".

To show the different criteria and effects of choosing samples in the traditional method and DIYexamer method, Fig.6 depicts the score distribution in a test. In this example, the highest score is 92, the lowest score is 34, and the average score is 69. The "high rank score group" and the "low rank score group" are chosen according to these two methods. Take student X as an example, the score of X is 66, which differs only 3 points from the average score. The associated information of X should have little, if not none, referential value in computing item discriminability. However, X is chosen as a sample in the high rank group in the traditional method. This fallacy results from using rank group, in terms of count, as the criterion of choosing samples. In DIYexamer, X is not chosen since score group, in terms of range, rather than rank group is used. Only those with large gap with the average score are chosen as samples.

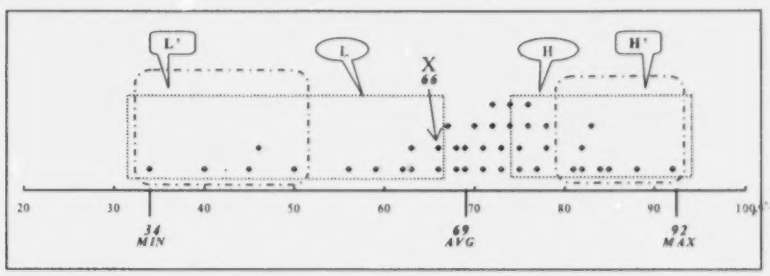

Fig 6: Comparison of samples taken in the traditional method and DIYexamer method

For different samples to have different impacts on discriminability, a referential value with respect to an item is generated for each student selected as a sample. We first define the item discriminability as the average of all associated referential values, as shown below:

$$\text{Discriminability} = \frac{\text{Sum of the referential values of sampled students}}{\text{Number of sampled students}}$$

Since the referential values depend on students' scores, the referential values are computed according to the ratio of correct and incorrect answers of the sampled students. The ratios of correct and incorrect answers are defined as follows:

$$\text{Ratio of correct answer} = \frac{\text{Number of items answered correctly}}{\text{Number of items on the test}}$$

$$\text{Ratio of incorrect answer} = \frac{\text{Number of items answered incorrectly}}{\text{Number of items on the test}}$$

TABLE 5: Principle to compute the referential value of a student with respect to an item

Student	Answer	Item discriminability	Referential value to compute discriminability
Competent (With high ratio of correct answer)	Correct	High	Ratio of correct answer
	Incorrect	Low	Ratio of incorrect answer
Less competent (With low ratio of correct answer)	Correct	Low	Ratio of correct answer
	Incorrect	High	Ratio of incorrect answer

According to Table 5, the referential value of a student correctly answered an item is the ratio of correct answer of the student. Alternately, the referential value of a student incorrectly answered an item is the ratio of incorrect answer of the student. This policy comes from the fact that an item should have increased discriminability if correctly answered by a competent student, while rendering decreased discriminability if correctly answered by a less competent student. In this way, a competent student contributes large referential value to a correctly answered item and small referential value to an incorrectly answered item, and vice versa.

C. Algorithm for DIYexamer's Discriminability Assessment

The test result of a student is used if the score falls in either the high or the low score group. A referential value is computed for each item the student answered. The discriminability of an item is the average of all of the associated referential values.

To calculate for each item, information must be recorded in the database. First, the highest and the lowest scores (i.e. Gmax and Gmin) of all students who answered the question item are recorded to calculate Gh and Gl. Gh and Gl are used as thresholds to determine whether a student is eligible to affect the rating of an item. Second, the number of students with referential values (i.e. n) and the sum of referential values (i.e. Accumulator) are recorded. The calculation formula and the corresponding definition of used parameters are listed below. Algorithm of DIYexamer's discriminability assessment summarized in Fig 7.

Accumulator: sum of referential values
n: number of students with referential value
T: number of correctly answered questions in this test
F: number of incorrectly answered questions in this test
Gmax: highest score of all students answered this question
Gmin: lowest score of all students answered this question
Gh: high threshold for ratio of correct answer
Gl: low threshold for ratio of incorrect answer
Ans: A Boolean variable indicates whether a student correctly or incorrectly answered the question

```
if((T/(T+F)>Gh) or (T/(T+F)<Gl))
{
 if  (T/(T+F)>Gmax)
   Gmax = T/(T+F)
 else(T/(T+F)<Gmin)
   Gmin = T/(T+F)
 Gh = Gmax-(Gmax-Gmin)*30%;
 Gl = Gmin+(Gmax-Gmin)*30%;
 n = n+1;
 if  (Ans==Correct)
   Accumulator = Accumulator + T/(T+F);
 else (Ans==Wrong)
   Accumulator = Accumulator + F/(T+F);
 Discrimination = Accumulator /n;
}
```

Fig 7: Discriminability assessment algorithm

5 Evaluation Of The Discriminability Assessment In Diyexamer

The fairness and performance of DIYexamer was evaluated. We conducted an experiment where 10 students took the test on-line using DIYexamer with 10 items. Table 6 summarizes the test results. Fig 8 shows the score distribution of the experiment. Discriminability for each item is computed using both the traditional method and the DIYexamer method. However, the discriminability originally falls between -1 to 1 using the traditional method, while falling between 0 to 1 using the DIYexamer method. To compare these two methods, both two ranges of discriminability are then normalized to 0 to 10, as shown in Fig 9.

According to Fig 9, the item discriminability differs in these two methods because the samples taken are different. The low-score group consists of student 1, 2, and 3 by the traditional method, while only 1 and 2 by the DIYexamer method. In this case, student 3 got 4 points, which differs from the average score (i.e. 5.2 points) by only 1.2 points. Since student 3 should have little, if not none, impact on the assessment of discriminability, student 3 is in fact not a proper sample.

Observe that, in Table 6, student 1 who is a less competent student and has incorrectly answered all items except item 1, and student 10 who is a very competent student and has incorrectly answered item 1. Thus, item 1 can be concluded as of low discriminability. Comparing the assessment results in these two methods, the computed item discriminability of item 1 is very low in the DIYexamer method but not as low in the traditional method.

Comparing item 3 and item 1 in Table 6, item 3 should have higher discriminability than item 1 because competent students tend to answer item 3 correctly and less competent students tend to answer item 3 incorrectly, which is not true for item 1. However, item 3 and item 1 have the same discriminability, i.e. 5, by the traditional method. In this case, the actual discriminability is more accurately reflected in the DIYexamer method than in the traditional method.

TABLE 6: Result of the test experiment

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Number of correct answers(score)
student1	1 (correct)	0 (incorrect)	0	0	0	0	0	0	0	0	1
student2	1	0	0	1	0	0	0	0	0	0	2
student3	0	1	1	0	1	0	0	1	0	0	4
student4	1	1	0	1	0	0	0	1	0	1	5
student5	0	1	0	1	0	0	1	1	0	1	5
student6	1	1	1	0	0	1	0	1	1	0	6
student7	0	1	1	1	1	0	0	1	1	0	6

student8	1	0	0	1	1	1	1	0	1	1	7
student9	1	0	0	0	1	1	1	1	1	1	7
student10	0	1	1	1	1	1	1	1	1	1	9

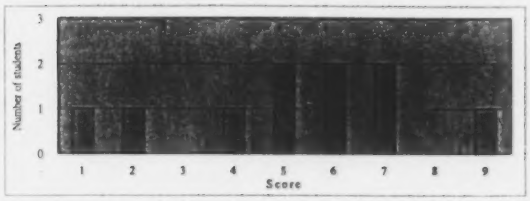

Fig 8: Score distribution of the test experiment

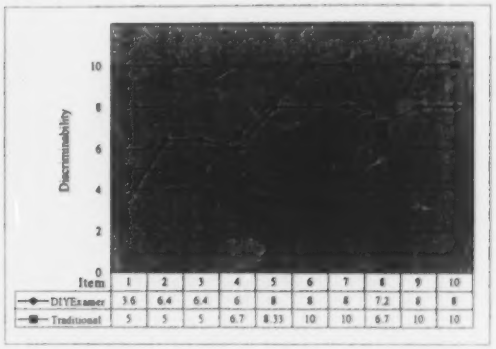

Fig 9: Comparison of item discriminability

6 Conclusion

This paper has presented a novel architecture for a networked CAT system, DIYexamer. It supports item DIY by students, item-bank sharing, and item discriminability assessment.

For discriminability assessment. new calculation formula were proposed. When compared with the traditional assessment scheme, the main difference is that the top and the bottom 30% of the *score* group, in terms of *range of scores* were selected rather than the *rank* group, in terms of *count of students*. Thus, item discriminability is more accurately reflected particularly when the tested students have close scores.

Item-bank sharing and item DIY by students has increased both the *amount* and the *variety* of questions in item-banks. Item DIY by students promotes *creative learning* within students, while automatic discriminability assessment assures better quality than traditional CAT systems.

A questionnaire was used to survey subjective attitudes of students about DIYexamer. As shown in Table 7, the outcome revealed that most students were interested in item DIY.

TABLE 7: DIYexamer questionnaire results: percentage and the number of students in parentheses of each question

Question	Strongly agree	Agree	No opinion	Disagree	Strongly disagree
Item DIY is interesting.	12.3 (7)	43.9 (25)	21.1 (12)	15.8 (9)	7.0 (4)
Item DIY is fanciful.	19.5 (10)	49.1 (28)	21.1 (12)	10.5 (6)	1.8 (1)
I am curious about the testing result of my DIY item.	26.3 (15)	59.6 (34)	10.5 (6)	3.5 (2)	0.0 (0)
I learned a lot when creating items.	12.3 (7)	47.4 (27)	22.8 (13)	17.5 (10)	0.0 (0)
I am curious about the teacher's opinion about my DIY item.	22.8 (13)	50.9 (29)	22.8 (13)	1.8 (1)	1.8 (1)
I am curious about other students' opinions about my DIY item.	15.8 (9)	56.1 (32)	21.1 (12)	7.0 (4)	0.0 (0)
I studied harder to prepare item DIY.	10.5 (6)	54.4 (31)	21.1 (12)	14.0 (8)	0.0 (0)
Judging the difficulties of my DIY items is easy.	40.4 (23)	38.6 (22)	14.0 (8)	7.0 (4)	0.0 (0)
Judging the fitness of my DIY items is difficult.	36.8 (21)	49.1 (28)	8.8 (5)	5.3 (3)	0.0 (0)
Item DIY by students comes from the laziness of teachers.	7.0 (4)	12.3 (7)	43.9 (25)	33.3 (19)	3.5 (2)
If possible, I hope such item DIY mode through the whole course can replace conventional testing.	1.8 (1)	10.5 (6)	35.1 (20)	38.6 (22)	14.0 (8)

Items generated by students are easier than by the teacher.	7.0 (4)	36.8 (21)	28.1 (16)	24.6 (14)	3.5 (2)
I knew more about the testing material after item DIY procedure.	8.8 (5)	50.9 (29)	22.8 (13)	15.8 (9)	1.8 (1)

The technique proposed herein is useful in general tuition not only to improve the quality of test items and fairness; but also to save time from generating questions and computing scores. We recommend that DIYexamer be popularized to schools.

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REFERENCE

[1] C. Bugbee, "The equivalence of paper-and-pencil and computer-based testing," J. of Research on Computing in Education, vol. 28, no. 3, pp. 282-299, (1996).
[2] C. V. Bunderson, D. K. Inouye, and J. B. Olsen, "The four generations of computerized educational measurement," in Educational measurement (3rd ed.), R. L. Linn, Ed. New York: American Council on Education—Macmillan, pp 367-407, (1989).
[3] S. L.Wise and B. S. Plake, "Research on the effects of administering tests via computers," Educational Measurement: Issues and Practice, vol. 8, no. 3, pp. 5-10, (1989).
[4] A. C. Bugbee, Examination on Demand: Findings in Ten Years of Testing by Computers 1982-1991. Edina, MN: TRO Learning, (1992).
[5] Load, F. M., Applications of Item Response Theory to Practical Testing Problems. Erlbaum, Hillsdale, NJ ,(1980).
[6] "Educational Testing Services Network", http://www.ets.org (accessed on Augest 22, 2000).
[7] "DIYexamer system", http://speed.cis.nctu.edu.tw/~diy (accessed on Augest 22, 2000).
[8] "Apache HTTP Server Project", http://www.apache.org/apache/ (accessed on Augest 22, 2000).
[9] "The Perl Language homepage", http://perl.com/ (accessed on Augest 22, 2000).
[10] L. Stein, "CGI.pm-a Perl5 CGI Library", Version 2.31, 2/8/1997, http://www-genome.wi.mit.edu/ftp/pub/software/WWW/cgi_docs.html (accessed on Augest 22, 2000).
[11] "GD.pm-Interface to Gd Graphics Library", Version 1.14, http:// www-genome.wi.mit.edu/ftp/pub/software/WWW/GD.html (accessed on Augest 22, 2000).
[12] "The Postgres95 homepage", http://s2k-ftp.cs.berkeley.edu:8000/postgres/ (accessed on Augest 22, 2000).
[13] "Red Hat Inc.,", http://www.redhat.com/ (accessed on Augest 22, 2000).
[14] Jacobs. L. C. and Chase, C. I., Developing and Using Tests Effectively: A Guide for Faculty. Jossey-Bass, San Francisco, CA ,(1992).

Empowering Secondary School Teachers to Effectively Exploit Internet Resources for the Enhancement of Teaching and Learning

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There are great potentials for the use of computers in the enhancement of teaching and learning in secondary schools, but in some subject areas, the realisation of these potentials is critically limited by the lack of appropriate educational software. Custom development of this kind of software is often not a viable alternative, since such a task is well known to be non-trivial and time-consuming that is frequently beyond the capacity of individual secondary school teachers. As computer science researchers and educators, we are aware that vast amount of teaching resources are freely available on the Internet. Such resources are often used by tertiary educators for enriching their teaching, but largely under-utilised by secondary school teachers. This paper reports our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources for use in their schools. Our approach is enabling in that it fosters participants' lifelong learning beyond the contents of the present course, and is applicable to a broader context than ours.

Keywords: **Teacher education, lifelong learning, program visualisation, algorithm animation**

1 Introduction

For a long time, educators and computer scientists have been exploring the use of computers in education [9]. The rapid drop in hardware price and the tremendous improvement in computing power in recent years have rendered computers more affordable to schools, teachers and students. Hardware is no longer the bottleneck that hinders the integration of information technology (IT) into the school curriculum. There are increasingly great potentials for using computers to enhance teaching and learning at all levels of education. In some subject areas, however, the realisation of these potentials is severely limited by the lack of appropriate educational software.

The development of good quality CAI software is well known to be a non-trivial and time-consuming task that calls for the combined expertise of programmers, experienced educators, graphics/multimedia designers, and others [10]. Such a task is often beyond the capacity of individual teachers in primary and secondary schools, due to their limited time, technical expertise and perhaps monetary resources. More fundamentally, it would not be realistic to require every teacher to develop their own CAI software from scratch for use. This is even true for most university educators. As Resmer [13] argues, "if every professor in a university had to write their own textbook, typeset it, print it, publish it, bind it, and distribute it before their students could use it, [textbooks] would not be a viable learning resource". Likewise, for widespread and effective use of computers in education, there is a need for teachers to be well informed of the source of available

educational software.

The Internet promises to be a source of many valuable teaching resources that are frequently available freely or at affordable costs. There are many advantages of exploiting Internet resources for use in teaching. Apart from cost savings, software tools on the Internet are more likely to be kept up-to-date as technology advances, and their evaluation versions could be put to trial use before making actual purchases.

By nature of their work, many university educators are accustomed to the exploitation of Internet resources for both research and teaching purposes [14]. In contrast, these resources have largely been under-utilised by secondary school teachers due to various reasons. Firstly, many teachers are not aware of the existence of such resources on the Internet. One example is the use of visualisation and animation tools that are great aids to program understanding. Although the existence and effectiveness of these tools have been well known to computer science researchers in the field, our experience is that few secondary school teachers are aware of this.[1] Secondly, teachers might not know where these resources are, even if they are aware of their existence. Blind searches on the Internet are likely to be inefficient and sometimes not productive, in terms of the time taken to retrieve useful materials. Thirdly, the use of some resources requires a level of technical competence that a typical secondary school teacher might lack. Finally, some software tools have to be adapted to suit the needs of individual teachers, and without any support or assistance, such tasks could be daunting.

In this paper, we report our experience in the design and delivery of a short course which aims at refreshing practising secondary school computer teachers with updated knowledge on teaching and learning with computers. We describe how we achieve our goals of providing practical assistance to computer teachers by empowering them to effectively exploit Internet resources. Our approach is enabling in that it fosters participants' self and lifelong learning beyond the contents of the present course. We believe that our approach is actually applicable to a broader context than ours and therefore would be of interest not only to secondary school computer teachers, but also to teacher educators and teachers of other disciplines at all levels.

The rest of this paper is structured as follows. Section 2 introduces the context and goals of our short course. Section 3 provides the background of the subject area: computer programming and visualisation tools. Section 4 describes how we exploit Internet resources for use in the course. Section 5 describes the implementation of the course and the feedback from participants. Section 6 discusses our approach. Section 7 concludes this paper.

2 The Teachers Update Course

2.1 Background and objectives

Our university has been organising the Teachers Update Course (TUC) annually as a service to local secondary schools. It aims at refreshing practising school teachers with updated knowledge on the subject areas they teach, and offering advice and assistance on the teaching and learning of the subjects. It serves to show our university's concerns to secondary education, to share our professional expertise, and to promote communication and cooperation between our university and secondary schools.

TUC consists of a series of half-day short courses that encompass many subject areas such as Use of English, Mathematics, Computer Studies, Physics, and others. This paper reports our experience in the design and delivery of the course on Computer Studies. Participants of the course were mainly secondary school teachers of computer subjects such as Computer Studies and Computer Literacy.

2.2 The local secondary school context

In Hong Kong, school teachers are often heavily loaded with both teaching and non-teaching commitments. Typically, a teacher has to conduct six to seven lessons per day, each lesson lasting for 35-40 minutes. In

[1] One author of this paper previously taught a class of student teachers in a Postgraduate Certificate in Education programme who were major in Computer Studies, and none of them were aware of the existence of program visualisation and algorithm animation tools. Similarly, none of the practising computer teachers who participated in the Teachers Update Course described in this paper were aware of such tools.

addition to such work as lesson preparation, setting and marking tests and examinations, most teachers have to share school administrative work as well as leading students to participate in extra-curricular activities. In recent years, the Government of the Hong Kong Special Administrative Region (HKSAR) has undertaken numerous initiatives to promote the integration of IT into the school curriculum [3]. Since teachers of computer subjects are usually more acquainted with the use of computers than other colleagues, they are often busily involved in the setting up and management of the IT infrastructure of their schools, and they are generally expected to assist other teachers in solving various problems in using IT.

Increasingly, there are pressures for teachers of all subjects to apply IT in their teaching activities. Many teachers have to spend a great deal of time after school hours to attend in-service IT training courses [8,9]. However, one common problem they encounter is the limited availability of appropriate educational software, and few of them have the time and expertise to develop their own courseware. Moreover, budgets are limited in schools for the purchase or development of courseware.

2.3 Goals and strategy

During the planning and preparation of the short course on Computer Studies, the following goals were formulated in an effort to maximise the usefulness of the course to the participants:

- *The course had to provide materials that are directly relevant to teaching in schools.*

  The course in the previous year was intended to broaden the computer knowledge of school teachers by providing updated information on multimedia and their applications. As such, the course was organised in the form of a condensed lecture of part of an undergraduate subject, supplemented by demonstrations of the applied research work of our staff in the area. Although the subject materials were interesting, many teachers subsequently indicated a preference of topics that are more directly related to their own teaching in schools. Simply acquiring further knowledge in the computing field was not as welcome as knowing something directly useful for solving the problems they encountered in their teaching.

- *The course had to offer practical assistance to teachers.*

  Considering the heavy workload of secondary school teachers, any teaching resources must be easy to use and demonstrably useful, or they would not be used at all. In selecting the course materials, preferences were given to those that are easily and practically applicable in the secondary school context. This strategy is also in response to the feedback by teachers in the previous year of their desire to learn something that is "more relevant [to their teaching]".

- *The course should motivate teachers' interests and empower them to pursue further via self-learning.*

  The course was a short one and naturally limited in the amount of teaching materials we could possibly provide. Even with a much longer duration, it would still be impossible to inform the teachers everything they had to know about the topic. Moreover, even for the same topic, there are considerable variations in their needs (for example, due to different teaching styles or their students' background). The same technique useful to one teacher might not work for another. What is more important is to foster their ability to pursue the topics further beyond what we offer, whenever they have the need to do so. Therefore, from the outset the course was designed to "have an empowering or enabling effect on the participants" [9]. We hoped that the course could enable school teachers to acquire what they need via self and lifelong learning.

Setting the right goals was important, but the real challenge was how to achieve these goals within a few hours of contact with the participants. We now outline our strategy as follows. Firstly, we selected a topic that would likely interest most computer teachers: computer programming and algorithms. This topic is clearly directly related to their teaching. Secondly, we collected useful information and software tools for the enhancement of teaching and learning of this topic. Most of these resources were originated from overseas and would be hard to access were they not put on the Internet. Thirdly, among them, we selected only those information and software tools that were judged to be practically useful in the local secondary school context. Finally, we demonstrated to teachers how they could have found and utilised these resources on their own through the Internet.

In retrospect, we believe that although the first step (topic selection) is important in ensuring the relevance

of the course, it is our approach in the remaining steps (use of the Internet resources) that would have more profound influence to the participants. Our approach will be discussed in detail in Section 6. Meanwhile, we briefly introduce the subject area in Section 3 and then elaborate on what we did in the course in Sections 4 and 5.

3 Computer programming and visualisation tools

3.1 Computer programming as a common major part of many computing curricula

Computer programming and algorithms is usually considered a significant and fundamental component in undergraduate computer science education [6]. In most universities, introductory programming and the design of elementary algorithms are the first courses that a computing major undergraduate student has to take (unless these courses were exempted due to credit transfer or advanced standing). Elementary programming courses are also frequently offered as electives to non-computing students with a broad variety of backgrounds [10].

At the secondary school level, computer programming is historically the major component of a typical computer subject. Although the emphasis of learning programming has now been reduced as compared to the past, there is, arguably, still a place for it to be included in the secondary school curriculum. In Hong Kong, both the Computer Literacy subject (offered to almost all junior secondary students) and the Computer Studies subjects (offered as electives to senior secondary students) include programming as a major part of the curriculum [2].

3.2 Difficulties of teaching and learning computer programming and algorithms

The teaching of computer programming and algorithms presents a great challenge to educators at both the secondary level and the tertiary level [15]. To understand a computer program or an algorithm, the student needs to have a good understanding of the internal execution model of computers, as well as the dynamics of variables, data structures and control flows in the algorithm [7]. Such concepts are abstract in nature and could be difficult to even novice programmers [16], let alone non-computing major undergraduates and secondary school students. Indeed, according to our survey to secondary school teacher participants of our short course, about 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.

There is usually considerable overlap between the contents of a computer subject in a secondary school and those of a first year course on computer programming in a university. As such, the difficulties encountered by secondary school teachers are in many ways similar to those faced by the professors in universities, as far as the teaching of basic computer programming and elementary algorithms is concerned.

Nevertheless, usually only the academically more capable students will enter universities. As a whole, the secondary school student population is less mature in intellectual development and more diverse in their academic ability. Compared with university students, many of the secondary school students tend to be less motivated and less capable of independent learning; they normally require more guidance in their studies.

Secondary school teachers are generally less well informed and possess far less resource under their disposal than university educators. To our knowledge, a great deal of research has been done in many universities to address the difficulties in learning computer programming and algorithms [1,5,6,7,12,15]. Unlike universities, however, secondary schools seldom have the resources and expertise to perform similar work to solve their problems. In fact, they might not be aware of such research activities. Our approach in the course is to facilitate the use of university resources on the Internet by secondary school teachers to solve their own problems.

3.3 Program visualisation and algorithm animation

Program visualisation refers to the use of graphical artifacts to represent both the static and dynamic aspects of a program [11]. Algorithm animation portrays the dynamics of the execution of an algorithm by means of animation tools [7]. Educators and researchers have long believed that visualisation and animation are useful in helping students understand the abstract concepts and dynamics involved in computer programming and

algorithms [15]. It is believed that visualisation and animation tools help the learners by displaying in concrete form the mental model of the execution of computer programs. Indeed, many universities worldwide have been actively researching and experimenting with the use of visualisation and animation tools. As a result, a variety of such tools have been developed for different purposes [1,5,6,7,12,15]. Many experimental results have been reported that favour the use of such tools for enhancing program understanding [6,7,15].

4 Exploiting Internet resources for useful educational software tools

Despite years of active research, program visualisation and animation tools are still not widely used in secondary schools, and few such tools designed for teaching and learning are available commercially.[2] As discussed in Section 2.2, it is often impractical for secondary schools to develop their own tools.

As computer science researchers and educators, we are aware that many program visualisation and algorithm animation tools have been developed as results of research work in various universities. Even though some tools have been developed mainly for demonstrating the research ideas and therefore might not have as many features as commercial software, most have been designed for teaching and learning. More importantly, they are usually available for free and easy access through the Internet for educational purposes. To our judgment, there are great potentials of utilising such tools in enhancing teaching and learning in secondary schools.

The idea of utilising research tools on the Internet for enhancing secondary school education is obviously appealing and has many advantages over acquiring similar tools by other means. We shall discuss these further in Section 6. However, before being convinced of the practicality of this idea, we had two concerns. Firstly, although these tools had been successfully applied in the tertiary education context, would they be useful in secondary schools as well? Secondly, would secondary school teachers be competent enough to make use of these tools that have originally been designed for use by tertiary educators who are technically more proficient?

To develop this idea further, we set out to evaluate the practicality of using Internet resources as teaching and learning aids in secondary schools. As program visualisation and algorithm animation do not fall into our own research areas, we started our search from only the scarce information that we had. Beginning with the Web sites of two well known researchers in these areas that we incidentally came across and made note of a few years ago, we followed links over links, and so on. It turned out that there was little difficulty in the search of relevant Internet resources. The more tedious and time-consuming task was to evaluate the contents of these resources one by one. Even so, within a few weeks' time, we were amazed to have collected and evaluated almost a hundred sites of related interest! These resources range from the innovative use of common spreadsheet software by researchers in the University of Helsinki [12], to ambitious laboratory projects such as the DYNALAB project of Montana State University [1], and university students' research projects such as Jeliot [5].

We selected and evaluated the resources according to several criteria: (1) relevance in content and level to the syllabus of secondary school computer subjects, (2) accessibility, (3) flexibility (customisability), (4) software and hardware requirements, (5) difficulty in technical content, (6) ease of setup and customisation. After evaluation, we decided to recommend about 30 web sites. The contents of these web sites range from ready-made animations of common algorithms, to downloadable program visualisation tools that support both forward and backward execution [1], and even online animation of user-defined algorithms using customisable 'actors' in a 'theatre-like environment' [5].

Through the process of selection and evaluation, we are increasingly convinced of the practicality of our approach. Many of the tools we found could be effectively used by people with some elementary knowledge of computer programming and concepts of program visualisation. Our participants were computer teachers who clearly possess knowledge of the former but not necessarily the latter. Therefore, part of our short course was to explain the program visualisation concepts and how they could be useful to aid program

[2] Although most commercial program development environments do provide some limited facilities such as the display of the contents of variables during program execution, these are primarily designed to aid software development (particularly to aid debugging) by programmers. These facilities are not targeted to beginner learners and usually not well suited for the purpose of teaching and learning.

understanding.

5 Course implementation and feedback

Our course began with discussions on the common problems in developing CAI software. Then we introduced various sources from which useful CAI software could be obtained freely or at nominal costs for topics in computer subjects in general. These sources included higher educational institutions, students pursuing higher education, professional educational bodies, textbook publishers and others. The use of these Internet resources was more straightforward and requires no further elaboration other than the provision of pointers.

Next, we introduced the concept of utilising program visualisation techniques for the enhancement of teaching and learning, and the corresponding selected Internet resources. For ready made animation tools that were straightforward to use, we simply provided pointers and made two representative demonstrations, leaving the participants to try and pursue the tools at their own pace after the course.

A few selected tools, however, were introduced in much more detail. These tools have one or more of the following characteristics: (1) they were technically more advanced; (2) they could be used in several ways to suit different educational purposes; (3) they had features that were particularly useful or illuminating; (4) their designs were based on notions that were innovative and less obvious to understand but practically very useful. Fortunately, the participants were mainly computer teachers whom could be safely assumed to possess the necessary programming skills and concepts to perform the required customisations. Were we to simply show the links of these resources, it could be difficult for them to tap the potential benefits of these tools effectively.

The participants were so interested in the selected Internet resources that the course was substantially overrun. At the end of the course, participants were requested to complete a questionnaire about their background (for planning of future courses) and about how well they felt the course had been organised (for evaluation of the present course). Some of the statistics obtained are as follows:

1. About 82% of the respondents agreed that computer programming and algorithms are the hardest topics to teach.
2. About 90% of the respondents agreed (with 26% strongly agreed) to the statement that "I will try to make use of the course materials at school when appropriate". None disagreed; the rest were undecided.
3. About 87% of the respondents agreed that the course was useful to them; none disagreed and the rest were neutral. The same number of respondents agreed that they were satisfied with the course. Some felt that the course could have been improved by extending the duration to allow more time for further discussions.
4. All respondents agreed that the demonstration of the Internet resources for teaching was the most useful part in the course.

6 Summary and discussions

6.1 Characteristics of our approach

We began with the ideas that program visualisation tools are useful for learning computer programming, but such tools are not widely known, of limited availability and hard to develop by secondary school teachers themselves. Yet Internet resources abound that could be effectively exploited for use in secondary schools. As researchers in the university, by nature of our work we are usually better informed with the availability of such resources and the advancement of the latest technologies. In planning and designing the short update course for teachers, we positioned ourselves as mentors in the search of relevant teaching resources. We aimed at offering practical assistance to secondary school teachers by providing the source of relevant information on the Internet, by demonstrating the potential benefits of utilising such information, and by guiding them through the solutions to the technical problems that might arise in utilising such information. We attempted to motivate the interests of participants, to help them overcome the initial barriers (that is, to make "jump start") so that they could eventually help themselves exploit the vast potentials of Internet resources via self and lifelong learning. Incidentally, in so doing, we have exemplified our course as an alternative model of "teaching in the information age" in which teachers serve more like a mentor than an

authoritative knowledge provider.

Our approach is characterised in several ways which distinguish it from that of a traditional teacher education course. Firstly, our goal was modest yet pragmatic in trying to address a specific but real problem that a typical secondary school computer teacher encounters daily: the difficulties of teaching computer programming. Secondly, we demonstrated to the participants how Internet resources could be effectively and practically utilised for addressing their problems. What is even more distinctive is the recommended use of tools developed by researchers with the latest software technologies of the field for use in tertiary education. We have argued that both tertiary educators and secondary school teachers share many common problems that call for similar solutions. Secondary school teachers could learn a great deal from the experience of educators in universities when dealing with their common problems. Finally, the course was designed to be enabling and empowering, with the explicit a priori goal that participants could pursue the subject further via self and lifelong learning.

6.2 Reflections and discussions

On completion of the course with encouraging feedback from the participants, we reflect on the factors contributing to our success. We note that a key factor is our decision to take advantages of the use of selected Internet resources, especially those from universities worldwide. Firstly, these resources are easily *accessible* to teachers and students alike, as long as they are connected to the Internet. The ease of access also minimises the problems that might occur in the distribution and installation of custom developed or commercial software. Moreover, the use of educational tools on the Internet is *cost-effective*. Many of these tools have been demonstrated to be effective through their use in universities. They are typically designed by computer scientists for demonstrating the advantages of applying their research ideas in education, and have subsequently been experimented and evaluated for continuous enhancements, with such evaluations adequately documented in their research papers. More importantly, they are available freely or at affordable costs. Cost is often a critical factor determining whether an educational software tool will be widely used in secondary schools, as resources at their disposal are usually fairly limited.

Some of the software tools we recommended were developed as prototypes with source codes publicly available [12]. They are usually based on sound theoretical principles and accompanied by technical or educational papers describing the theory and implementation in detail. Teachers may customise these tools to suit their specific needs that might vary due to differences in teaching styles, objectives, and students' backgrounds. They may choose to use the whole or part of the tool, or write small program components to be integrated with these tools. For computer teachers who are acquainted with and probably interested in writing programs, such "lightweight customisation" is usually easier and more feasible than building a complete CAI system from scratch. Customisation by users is not normally adequately supported by commercial software that comes with no source code and only limited documentation such as operational guides.

Technologies and knowledge have been advancing very rapidly. On the Internet, new resources keep emerging as results of continuous research by academics who explore the latest technologies for the enhancement of teaching and learning. An example is the experimentation of using 3D visualisation, multimedia and virtual reality technologies in education as they emerge [4]. Teachers who are well informed of such activities through self-learning on the Internet will be in a better position to make use of the latest research results and technologies for continuous improvements to their teaching and learning in ways that are not otherwise possible.

The use of research tools for teaching and learning is not without problems. However, most of these problems would not be deterrent; they could be solved or avoided. Other problems are present in the use of other sources of educational software anyway. For instance, research tools are often imperfect, with some functionality not fully implemented; but as long as the implemented features are considered useful, the tools can be used in part rather than in full. There might be a lack of instant technical support, but many researchers who develop the prototypes are keen to collect feedback, as these might be crucial for their continuous research work. Inevitably, frequent revisions might occur to these tools for research purposes, but if the teacher finds an earlier version useful, that version could be downloaded and kept for use instead of relying on its availability at the source.

7 Conclusions

University educators possess the necessary resources, expertise and freedom to fulfil their roles of performing experimentation and researches, and producing prototypes to demonstrate the usefulness of their innovative ideas. In comparison, secondary school teachers are too occupied with teaching activities and other professional commitments. Most teachers cannot afford the purchase of expensive commercial software for teaching, nor do they generally have the capacity of developing appropriate educational software on their own. Success of integrating IT in the school curriculum is critically determined by the availability of easy-to-use and adaptable tools that satisfy the diverse needs of teachers and students of a variety of backgrounds in different contexts.

The Internet has provided a medium on which tertiary educators can make their resources and experience publicly available to be shared by all, including secondary school teachers. Around the world, numerous tertiary educators have gladly done so as part of their service to the community. Unfortunately, such resources are largely under-utilised by secondary school teachers, due to reasons such as the lack of knowledge and technical competence. For computer teachers, these barriers are relatively easy to overcome, as long as appropriate support and assistance is provided. For teachers of other disciplines, more help might be required. Ultimately, secondary school teachers have to learn, adapt and use these resources by themselves, and to keep themselves updated via self and lifelong learning to respond to the rapid changes that the world has been undergoing.

In this paper, we have reported our experience in the design and delivery of a short course that has progressed towards this direction. Our course also exemplifies itself as one possible model of "teaching" as "facilitating the self and lifelong learning of the participants". Most tertiary educators have now become regular users of Internet resources for enhancing their teaching and learning. It should not be long before secondary school teachers have to follow suit. What we have contributed is but a small part of the continuing collaborative effort to empower teachers to use IT effectively in secondary schools, and ultimately to better education of our younger generations.

References

[1] Boroni, C. M., Eneboe, T. J., Goosey, F. W., Ross, J. A. and Ross R. J. (1996). "Dancing with DynaLab – Endearing the science of computing to students". In *Proceedings of the Twenty-Seventh SIGCSE Technical Symposium on Computers Science Education (SIGCSE'96)*, 135-139, Philadelphia, USA, February 1996.

[2] Curriculum Development Council (1993). *Syllabuses for Secondary Schools, Computer Studies (Secondary 4-5)*, Hong Kong Government Press.

[3] Education Manpower Bureau (1998). *Information Technology for Learning in a New Era: Five-year Strategy 1998/99 to 2002/03*. November 1998, HKSAR.

[4] Gloor, P. A. (1998). "Animated algorithms". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (eds), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[5] Haajanen, J., Pesonius, M., Sutinen, E., Tarhio, J., Terasvirta, T. and Vanninen, P. (1997). "Animation of user algorithms on the Web". In *Proceedings of IEEE Symposium on Visual Languages (VL'97)*, 361-367, Isle of Capri, Italy, September 1997.

[6] Kalayar, M., Ikematsu, H., Hirashima, T. and Takeuchi, A. (1999). "Intelligent learning support system for algorithm learning". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 840-843, Chiba, Japan, November 1999.

[7] Kann, C. and Lindeman, R. W. (1997). "Integrating algorithm animation into a learning environment". *Computers and Education*, **28**(4): 223-228.

[8] Kong, S.-C., Au, W.-K. and Pun, S.-W. (1999). "A case study on the implementation of information technology education pilot scheme in Hong Kong". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 27-34, Chiba, Japan, November 1999.

[9] Law, N., Wan, J., Lau, M. F., Lee, R. and Yuen, A. H. K. (1999). "Towards a model of IT training for inservice teachers". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 51-58, Chiba, Japan, November 1999.

[10] Mulholland, P. and Eisenstadt, M. (1998). "Using software to teach computer programming: Past, present and future". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[11] Price, B.A., Baecker, R.M., and Small, I.S. (1993). "A principal taxonomy of software visualisation". *Journal of Visual Languages and Computing*, **4**(3): 211-266.

[12] Rautama, E., Sutinen, E. and Tarhio, J. (1997). "Excel as an algorithm animation environment". In *Proceedings of Annual Joint Conference Integrating Technology into Computer Science Education (ITiCSE'97)*, 24-26, Uppsala, June 1997.

[13] Resmer, M. (1999). "IMS – Distributed learning standards". In *Proceedings of 7th International Conference on Computers in Education (ICCE'99)*, **2**: 567-570, Chiba, Japan, November 1999.

[14] Sloane, A. (1997). "Learning with the Web: Experience of using the World Wide Web in a learning environment". *Computers and Education*, **28**(4): 207-212.

[15] Stasko, J. and Lawrence, A. (1998). "Empirically assessing algorithm animations as learning aids". In Stasko, J., Domingue, J., Brown, M. H. and Price, B. A. (editors), *Software Visualization: Programming as a Multimedia Experience*, MIT Press, Cambridge, MA.

[16] Yu, Y. T. and Poon, P. L. (2000). "An approach for evaluating the quality of software developed by novice programmers". In *Proceedings of the 4th World Multiconference on Systemics, Cybernetics and Informatics (SCI'2000) and the 6th International Conference on Information Systems Analysis and Synthesis (ISAS'2000)*, **2**: 485-490, Florida, USA, July 2000.

Examining Problems of Student Teachers to Build a Web-supported Environment

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Student teaching is an important part of teacher training programs. With the emerging and the widespread use of the Internet, it is important to consider how this crucial stage of teacher development can be facilitated by the use of the technology. In order to create for a user-oriented and research-based web environment, this project was designed to explore problems that student teachers experience. During the internship year, student teachers filled out a self-report critical problem questionnaire five times in two periods, one in each semester. The student teachers were asked to pick one critical problem that they had tried hardest to solve in the day or the week. In the survey, they wrote down the ways to solve the problem as well as the resources they used in the process. The results showed that peer student teachers were those whose help were mostly sought. Over 90% of the means to solve the problem was face-to-face. It is summarized that student teachers may need three types of proximity for problems: Professional, emotional and physical. To provide rich interpretation to the problems, it is suggested that an experience database with focused case study discussion forum may be of help to student teachers' problems.

Keywords: **Student teacher, Student attitude, Teaching experience, Internet use**

1 Introduction

Student teachers are in the process of becoming a teacher. Fresh from the university, student teachers are often full of ideals and enthusiasm. Entering the real world of teaching, however, they are likely to experience problems and difficulties that can be termed "reality shocks" (Wubbels, Creton, Hooymayers & Holvast, 1982). With the Internet technology becoming more accessible and versatile, there are an increasing number of web-based projects to assist student teachers (Georgi & Crowe, 1998). Instead of building the technology first and assessing the student teachers later, this project intends to design a research-based and student teacher-oriented web environment.

This study proposes to examine the needs of the student teachers and use the results as basis to construct a web environment. During a one-year internship, a class of 76 student teachers were asked to participate in the survey and interviews for their problems and difficulties, as well as the resources they used to resolve their problems. The analysis of the problems will be used to develop the guidelines and the structure of the website.

2 Theoretical Background

2.1 The problems of the student teachers

Numerous studies have been done to understand the problems and "reality shocks" that student teachers encountered. In an extensive review, Veenman's (1984) collected 91 research studies in the last two decades.

His summary of the findings suggested eight categories of problems, including managing student, motivating students, dealing with individual differences, evaluating students' work, communicating with parents, organizing class work, obtaining supply and teaching material, and tackling individual student's problems. Chen & Chen (1999) critiqued the previous researcher-designed surveys and used student teacher's journals as a means to understand their problems. They collected 800 student teachers' journals and used Multidimensional Scaling to analyze the data. The major categories of student teacher's reality shock included status uncertainly, students' attitudes and disciplines, conflicts between the decision maker and the doer, the negative-reinforcement style of management, the working ethics of teacher and staff, as well as the relationships among school members (Chen & Chen, 1999).

While many studies addressed the problems that student teachers encounter, most of them focused on why the problems occurred and how to solve the problems for them. Very few, on the contrary, investigated how student teachers solved their problems. Questions regarding whom student teachers asked for help and what resources they used in solving their problems were seldom discussed. The purpose of study, therefore, is not to postulate another possible cause of the problems, rather, is to find out what resources student teachers use to solve their problems, and how technology can help expand this access.

2.2 The problems with the technology

The use of Internet technology for teacher training has received growing attention. E-mail is perhaps still the most widely used means to encourage communication between the supervising teacher and student teachers (Nabors, 1999). More recent developments include more sophisticated design such as electronic portfolio to promote reflection and performance-based assessment (Georgi & Crowe, 1998). Morley's (1999) project uses WebCT, an Internet-based interface, for course syllabus, class notes, hyperlinks, as well as bulletin boards for faculty and students in pre-service method courses. The National Science Council in Taiwan in recent years has funded several projects in building web-supported environment student teachers in areas such biology, math, science and technology (Guo, 1999).

When new technology is added to student teaching, however, some precautions are warranted. As an add-on, the help it provides may not be critical to the user's needs nor adopted by the user in a long run. Examples can be observed in many websites where only few messages are found in the discussion area. As Hsu & Bruce (1998) observed, teachers in distance education often fail to communicate with their distance students because their pedagogical strategy with the new technology does not supply the necessary cues that is acquainted by the students in their face-to-face environment. Therefore in this project we want to explore student teachers' current situation before designing the website.

3 Methods

A total of 35 student teachers from 11 subject areas of junior and high schools participated in this one-year study. The participants were all recent graduates from university or graduate schools of the same university. To sample the student teacher's experiences with problems and difficulties across the internship year, the critical problem survey involved two rounds of sampling periods, once in the end of the fall semester and once at the end of the spring semester.

During the first semester, student teachers were asked to fill out a questionnaire once a week for five weeks. Every week they had to pick one most critical problem in the past week. Three open-ended questions were designed to elicit the most critical problem that demanded the most of the student teachers' time and energy to solve. The three open-ended questions were: 1) What is the most critical problem you have experienced during the week? 2) How do you resolve the problem? And what resources do you use? 3) At the end of the week, was the problem resolved? If not, how would you like it to be solved?

In addition to the open-ended questions, there was a chart where student teachers had to check boxes for the people they had talked to regarding to the problems they were trying to resolve. The choices included the cooperating teacher, the supervising teacher, the student teachers in the same subject area and different subject area from the same university, the student teachers in the same school but from different university, the family, the roommate, none, and others. They were also asked how many times they have made the contact and by what means the communication was made. The choices included face-to-face, phone, e-mail, and others.

The questionnaires were first mailed out to the student teachers. After the initial data collection, it was found that the returned rate was too low. Therefore, additional short telephone interviews with 25 students were arranged. The interview also provided a little more in-depth background for their problems and difficulties. At the end of the spring semester, the same questionnaire was filled out daily for five days with the help of telephone interviews. Regular attendance to the student teacher's monthly meeting and small group discussions also informed the interpretation of the data collected.

4 Results

4.1 Student teacher's problems

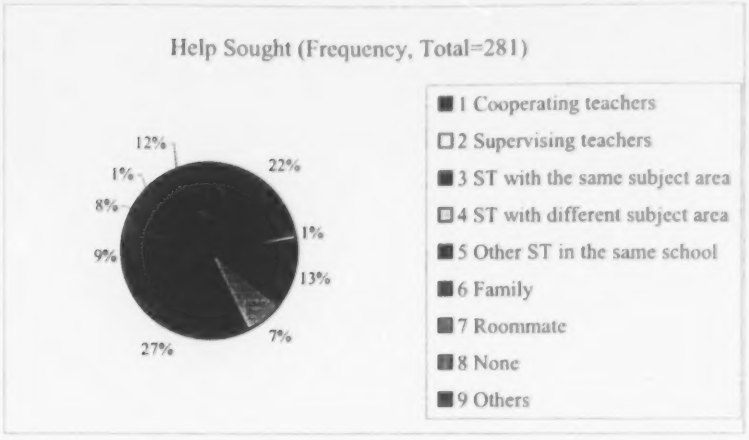
The results of the self-reported questionnaire and the transcript of the interview were coded by two researchers and two research assistants. The coding scheme originally used was Chen & Chen's (1999) findings of six categories, but the emerging themes of the data yields to the following four major categories in student teachers' problems. 1) Ambiguity of the status, including conflicts with the cooperating teachers for competing authority in the class; conflicts with school administrators in terms of task assignment; and conflicts with the school culture in terms of the feeling of unfit to the school physical environment, goals, and life styles. 2) Lack of professional knowledge, including subject knowledge, teaching skills, class management skills, and skills for student discipline problems. 3) Relationship with cooperating teachers, administrators, and students; including problems in making their needs known; and in dealing with small groups and gender issues. 4) Confusion in teaching as career goals, including conflicts between the ideal and reality.

4.2 Ways to solve the problems

When stressed by a problem, student teachers did not always know how to solve it. They usually consulted people for solutions. Categories of people whose help were sought after were coded from both the questionnaire and the interview. 1) Cooperating teachers, to ask for assistance or professional suggestions on classroom management and teaching skills. 2) Other teachers of the same subject area, for content knowledge and student discipline problems. 3) Other student teachers, to seek answers and condolence from others about conflict with the cooperating teacher and students' disciplines; also for relationship and cultural adjustment. 4) Solving the problem by oneself, such as trying out ones' own new ideas, making more effort to learn new things, adjusting attitude, accepting the reality, or simply enduring it.

Depending on the nature of the problem, other resources were sought for specific information. For legal issues, for example, some student teachers sought help from higher up authorities. In terms of technology, a few student teachers used the Internet to find teaching material and lesson plans. Not every problem had a solution, however. During our talk during the interview and in informal settings, quite a few students indicated that they often choose to passively accept the situation or to give up thinking for solutions. The following figure is a summary of the results from the questionnaire about the help the student teachers sought (see Figure 1). The results showed that about 47% of talks were with the other student teachers, where 27% were from the student teachers in the same school. About 22% of help was received from the cooperating teacher, and another 17 % were from family and roommate. Only 1% was from their supervising teachers. Among all the communication means, 92% were face-to-face, 6% were by phone, and 2% were by e-mail.

Figure 1 People whose help student teachers sought from



5 Discussion

According to the analysis, the problems of student teachers ranged from personal to professional. The solutions, although ranged from professional guidance to personal camaraderie, are limited to face-to-face communication. To contemplate what will help student teachers in solving their problems, it may be useful to postulate what they needs are. 1) Professional proximity. Being a novice, a student teacher may eager to know how others would have done differently. Those who are authoritative in professional fields, such as cooperating teachers, are likely to be pursued for instructional and managerial guidances. 2) Emotional proximity. Besides professional guidances, student teachers need to find emotional support to feel that they were not alone. It is also safer to talk to peers for issues of role adjustment and interpersonal relationships in schools. 3) Physical proximity. Those who are physically close (66%) are more readily to help. Therefore, when physical gatherings are not available, the help seeking channels can become seriously impeded.

Based on the above findings, we can begin to think about the design of a web-supported environment. The employment of a student teacher website should have features that provide additional or alternative support that take the above three types of proximity into account. The complexity of the problems and the limited access to solutions suggested that a case method that the user can criss-cross for multiple interpretations may be appropriate for learning in a complex knowledge domain (Spiro & Jehng, 1990). The following components are proposed in the website to be built. 1) A student-teaching case database. To provide experiences of other student teachers in a form of journals, including description of and reflection on various aspects of student teaching. This database is both outlined and keyword searchable. Hyperlinks to other similar cases can be also built. Student teachers can access to a peer's life lessons without having to have an appointment with him. 2) Guidelines and suggestions. Also included in the database are written guidelines and suggestions from academics, experts, experienced teachers and student teachers on the same topics as the above case database. Links to other web resources regarding professional information will also be added. Student teachers can reach specific information for guidance without much effort. 3) Focused case study discussion forum. To provide threaded bulletin boards on selected cases from the database. With shield identity, student teachers can find emotional support without being exposed. The cases can be rotated on weekly bases and among different subject matters. 4) Annotated video components of teaching. Also included in the database can be video clips of exemplar teaching of cooperating teachers as well student teachers' teaching. Written comments can be added by both the cooperating teachers and supervising teachers. This is a good place to engage a productive conversation among the triad of the student teacher, the cooperating teacher, and the supervising teacher.

It is hoped that with the aid of the technological power, the student teachers will have better chances to solve their problems and they should feel more empowered in their first full-time exposure to the real world of teaching.

References

[1] Chen, F. C. & Chen, H. L., "The experience of probation teacher's reality shock--The first season analysis." Proceedings of the Conference on the Exemplar and Practice of Educational Internship. Taipei, Taiwan, April 30-May 1, pp. 51-74, (1999).

[2] Georgi, D. & Crowe, J., "Digital Portfolios: A Confluence of Portfolio Assessment and Technology." Teacher Education Quarterly, Vol. 25, No. 1, pp. 73-84, (1998).

[3] Guo, Y. W., "Planning and promotion of the research on improving the science teacher quality." National Science Council Monthly, Vol. 27, No. 8, pp. 866-880, (1999).

[4] Hsu, S. & Bruce, B., "The missing borders: Pedagogical reflections from distance education." Teaching Education, Vol. 10, No. 1, pp. 47-54, (1998).

[5] Morley, L., "Expanding preservice teachers' tools for effective teaching." Paper presented at the Annual Conference on Technology in PE and Sport. Chattanooga, TN, USA, July, (1999).

[6] Nabors, M. L., "New functions for "Old Macs": Providing immediate feedback for student teachers through technology." International Journal of Instructional Media, Vol. 26, No.1, pp. 105-107, (1999).

[7] Spiro, R. J. & Jehng, J. C., "Cognitive flexibility and hypertext: Theory and technology for the nonlinear and multidimensional traversal of complex subject matter." In D. Nix & R. Spiro (Eds.), Cognition, education, multimedia. NJ: Lawrence Erlbaum Associates, (1990).

[8] Veenman, S., "Perceived problems of beginning teachers." Review of Educational Research, Vol. 54, No. 2, pp. 143-178, (1984).

[9] Wubbels, Th., Creton, H. A., Hooymayers, H. P., & Holvast, A. J. C. D., "Training teachers to cope with the 'reality shock'." Studies in Science Education, Vol. 9, pp. 147-160, (1982).

Implementing Modern Approaches to Teaching Computer Science: A Cross-Cultural Perspective

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Western research recognises [1] within the CS academic community pressure on its curriculum and teaching methodology brought about by the "evolutionary" nature of the discipline. This continuing need to avoid obsolescence in curriculum, which is produced by changing needs of industry and advances in research, is accompanied by other international and more local issue issues. Current research identifies several techniques which may be used to motivate and support CS learning in such an environment. This paper examines the implications of these findings to Asia, and particularly to mainland China, based on the personal reflections of this researcher on her own studies in China.

Keywords: **Computer Science Education, Cross-Cultural**

1 Areas of concern in Western CS education

Some modern issues of concerns in CS education [1] include attrition due to poor motivation/learning difficulty at CS1 level, dealing with students from a wide range of backgrounds with different learning styles and teaching the problem-solving and lifelong learning skills demanded by industry and research

2 Physical solutions

2.1 Providing Motivation Through Active And Participatory Learning

Active [2] and participatory learning [3] are techniques that are proposed to help motivate learners. Some methods which can be used include providing opportunities in "modified lectures" for paired response to questions posed by the lecturer or students discussing the notes they have taken during the lecture and helping to correct misunderstandings. Others have used role-play to demonstrate structures and protocols eg. arrays, linked lists or token passing protocols.

2.2 Learning programming through pattern recognition

In dealing with the learning of programming at the basic level, many researchers have examined the issues of teaching CS1. There is much interest in the use of patterns in aiding students' comprehension of basic programming and the integration of this knowledge [4 Clancy & Linn].

Clancy and Linn comment on the fact that design patterns are of great importance in software engineering and OO design and that to, to some extent, programming knowledge consists partially, at the cognitive level, as patterns (or schemas). However they show that, while the use of patterns is helpful in integrating knowledge, new programmers do not naturally infer patterns and sometimes find it difficult to understand "expert patterns". Clancy and Linn [4] and Johansson [5] advocate the use of a wide-range of contextualised examples and case studies to support the teaching of basic programming skills.

2.3 Adapting pedagogical styles to deal with social, cultural and gender issues

Research shows that students from different cultures or of different genders display different attitudes to computers and learning. In a two-year study of female and international CS students at Carnegie Mellon

University [6] issues which arose included the perception by some female students that the 'purpose' of computing needed to be defined within introductory CS courses. While they displayed a high-level of interest in the computing process they needed to be able to contextualise this process "within a larger purpose". They also displayed a lower level of "attachment" to their computers than did male students on the same course and expressed some relief as they discovered that CS education covered a wide-range of topics

Other research [7] [8] points out that there is a link between culture and learning style. Assertions made in this research indicate that Chinese students (studying overseas) would find it easier to understand and apply theoretical principles within programming than would a similar group of Western students. In their study, Fisher, Margolis and Miller [6] discovered that international female students on their course showed the least "attachment" to computers or computing and used pragmatic reasoning (such as employability) for their choice of major.

The conclusion here is that some allowance has to be made for cultural and gender preferences within the teaching of CS. While it is possible to provide an inclusive focus within lectures, there is, however, some may be a more pressing need to be able to adapt tutorial material for different styles and preferences.

2.4 Problem-solving for lifelong learning

It has been noted [9] that many students who have difficulties across the first year of CS as a whole do not know where to start with a task, regardless of the subject area.

Some effort has been made to incorporate training in problem solving skills and techniques in to early CS education to deal with this problem . This ranges from the use of Edward de Bono' s tools for lateral thinking to the development of Polya' s approach of Understand, Design and Review [9] for problem solving and offering courses in these techniques within, or parallel to, early programming subjects

2.5 Web-Mediated solutions

With the problems imposed by large classes, and the large range of individual approaches needed to deal with some of student learning issues raised above, CS academics have been some of the first to develop and use web-mediated learning environments for enhancing student learning in CS.

As I have pointed out ([8], [9]) the Web provides a vehicle for the development of the learning environment and teaching can be structured to develop lifelong learning skills and to cater for the expectations and learning styles of students from different cultures and backgrounds.

Early Australian examples of this style of teaching in CS education are many. Recent Australian examples of the use of the WWW in CS education abound. Boalch [10] provides an examination of the use of the WWW as a support medium for the delivery of a first year unit in Information Systems at Curtin University. He provides an evaluation of site utilisation and user feedback in the case where subject information and course details were provided on the WWW for students.

The Eklunds [11] examine the use of the WWW to supplement traditional IT teaching. They provide case studies of two examples of the re-structuring of traditional forms of IT course for Web-delivery. Jones [12] of Central Queensland University gives details of case study involving the design, presentation and evaluation of an undergraduate unit in Systems Administration taught completely via the WWW to on-campus and distance students.

3 Reflection on CS Education in Mainland China

The following two stories are taken from some interpretive tales which I wrote after two separate periods of studying and teaching in China. They draw a picture of the role of the computer on campus in Nanjing 1995) and in Jinan (1998).

A Visit To The Computer Centre 1995

I managed to pay a visit to the University Computer department (I was a Computer lecturer myself at the time in Australia). This was a definite culture shock. The computers, 386s and old at the time, were

kept in a special air-conditioned and carpeted room. People wore white coats and slippers if they wanted to use them. Most students (and only the best study computers) were doing basic Basic programming. I tried to investigate whether they used Windows, or anything modern, but the lecturer was only interested in the length of computer courses in Australia. There seemed to me to be no parallels in our courses at all. The students seemed only to learn Basic programming *[I wondered what job this would qualify them for!]*. It seemed to that things like word processing *[the Chinese have a special keyboard and it takes 5 keys together to create one character]* were a matter for female secretaries and did not enter the arena of the university. I tried to explain the issue of the 'computer as a tool' but I could see that the body language was saying 'Crazy Westerner!' when I tried to put across the concept of teaching less-able, or even all students, to use computers. Computers are for the young and highly intelligent in China.

A Visit to the Internet Centre 1998

It was surprised to find the computer was still as remote as ever from the everyday life of the average student. Computers, 486s by now, still lived in splendid isolation in carpeted rooms, and students still wore special slippers to use them. Still no Windows and still basic Basic.

I had imagined that the cutting edge of technology would be a little different to that which we had at home. I was a little surprised though to find out the process which I had inadvertently become involved with. I worked for six weeks with some highly creative young teachers to try and develop an intranet from an old CAD classroom (486s with no hard disks), one modern Pentium in a building several hundred metres away, one modem and a collection of legal and not-so-legal software. The Internet Centre turned out to be a heavily guarded room about the size of an average Western kitchen with a little row of computers along one wall, filled with a large collection of discarded technology and useful pieces of wire.

Major problems for the Chinese academics was their lack of ability in reading English as the 'install' dialogue boxes sped past on the screen. The problem for me was that I read Chinese much more slowly than they could read English. All the online-help in the world did not help us, installation was a slow process! We often laughed at the problems because we were all engineers and computer scientists. Not really the type of people who are famed for their linguistic abilities, but the monopoly of the Internet by the English language is certainly a problem in China.

I left before the networking was done. I did manage to complete a bilingual virtual library and an English home page for the Institute (with the help of some young teachers) and to teach a couple of them to use FrontPage. I gave lectures to many of the final year students and their teachers. Certainly no lack of enthusiasm here – just a lack of technology and English teachers!

3.1 Chinese Teaching Practice and Computer Based Education.

The combination of a Confucian philosophy and commonly accepted teaching models means that, in universities and colleges, all subjects are taught lecture-style to large groups. However to a Western none of the common CS teaching problems established above is observed in daily teaching and research.

From a Western perspective motivation remains very high among students as they strive to master modern hardware and software. Gender issues and the ability to attract female students do not appear to be a great concern and classes appear to display a balance between males and females. Learning problems do not appear to be the major difficulty experienced and researched in the West.

The major problem appears to be curriculum. The Chinese system has been one that has relied on a national curriculum in all sectors of education and changes in the software and hardware used and taught have not been allowed. During April 1998 (China Daily, 1998) the Ministry of Education announced major adjustments in the University system with corresponding changes to the High School curriculum and schoolbooks, which provide some hope that this issue will be addressed.

A national curriculum which has not kept pace with changes computing practice in Chinese industry and commerce, and even the home, has caused a demand for Western computer manuals in Chinese translation and the increase in number of private providers offering training in modern computer applications and the Internet. Many young teachers and their students are becoming competent users of modern software (eg Windows 98/NT, Office97, object-oriented software) which is not available within the Higher Educational system by turning to these private providers. This leads to disaffection and difficulties for both teachers and their students.

3.2 The Future

As well as the obvious improvements to connections, access speeds and call charges which are currently being made by CERNET, wider issues to be faced are the development of Chinese language software and WWW pages to improve the take-up of the Internet in China as a whole. This is being carried out in an environment of large-scale educational reform which will need to take into account the effect of the Internet on accepted Chinese teaching practice and pedagogy.

4 Conclusions

It is hard to imagine that, even within the next ten years, the Chinese economy might begin to develop and maintain a systemic hardware and software infrastructure within higher education. While it is easy to envisage the limited availability of the Internet for research students, and especially in the nationally funded universities and those around Beijing, the provincial lecturer has the doubly difficult task of persuading the older and therefore more powerful academics to accept new technology and to make drastic changes to their teaching style to incorporate it.

I have proposed elsewhere [9] that an effective conceptual framework for the development of an online learning environment might be one which is based on expected pedagogical outcomes. Therefore one model for China would be to concentrate on the development of online teaching content which would be a resource for guided and collective discovery learning (see above). This might begin with the development of Chinese language link pages to English language resources such as comprehensive virtual libraries and databases.

Academic staff development in technology is both very easy and very difficult. Young Chinese academics are as adept as their Western counterparts in their understanding and use of cutting-edge technology. Their progress is however hampered by their English language skills. This is especially apparent when one is made aware of the lower standards of English language required for technical subjects and the datedness (or nonexistence)of the technical vocabulary taught at university level. This appears to be one of the most pressing problems for the Chinese universities to grapple with and solve.

CS education research has shown a need for pattern recognition, motivation and problem solving skills as aspects of life-long learning. These can be supplied through the medium of web-mediated adaptive tutoring which can be used to augment face-to-face teaching but great efforts will need to be made to use these effectively within the current Chinese pedagogical framework.

References

[1] Tucker, A.B. "Strategic Directions in Computer Science Education". ACM Computing Surveys, **28**(4), (1996).

[2] McConnell, J.J. "Active Learning and its use in Computer Science." Integrating Technology into C.S.E. Barcelona, Spain, (1996).

[3] Jenkins, T. "A Participatory Approach to teaching Programming." *ITiCSE*, Dublin Ireland, (1998).

[4] Clancy, M.J. & Linn, M.C. "Patterns and Pedagogy." SIGCSE, New Orleans, USA. (1999)

[5] Fisher, A., Margolis, J. & Miller, F. "Undergraduate Women in Computer Science: Experience, Motivation and Culture". SIGCSE97. (1997)

[6] Cobern, W.W. "World view theory and science education research." NARST Monograph No. 3. Manhattan, KS: National Association for Research in Science Teaching. (1991)

[7] Slay, J."Unpublished Ph.D thesis". Perth,WA: Curtin University of Technology. (2000)

[8] Slay, J. "Using the WWW to Create an Effective Cross-Cultural Learning Environment. Hong Kong Web Symposium 98, Hong Kong University. (1998)

[9] Slay, J., "Using the World Wide Web to Create Foundations for Lifelong Learning - An Australian Perspective." Teleteaching, IFIP World Computer Congress98, Vienna. (1998).

[10] Boalch, G. "WWW as an Educational Support Medium: An Australian Case Study." Paper presented at AusWeb96, Gold Coast, Australia, (1996).

[11] Ecklund, J. & Ecklund, P. " Integrating the Web and the teaching of technology: Cases across two universities." Paper presented at AusWeb96, Gold Coast, Australia. (1996).

[12] Jones, D. "Solving some problems of University Education: A Case Study." Paper presented at AusWeb96, Gold Coast, Australia. (1996).

Initial Evidence for Representational Guidance of Learning Discourse

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Little work to date has addressed the effects that problem/solution representations have on collaborative learning processes. This paper outlines empirical and theoretical reasons why the expressive constraints imposed by a representation and the information that a representation makes salient may have important effects on students' discourse during collaborative learning. It then reports initial results from a pilot study. Students worked together in pairs on hypertext-based "science challenge" problems. Pairs used either free text, matrix or graph representations of evidence, with two groups assigned to each kind of representation for a total of six groups. Analysis of discourse transcripts suggests that these representations have quite different effects on the extent to which students discuss evidential relations.

Keywords: **Collaborative Learning Discourse, Representational Tools**

1 Introduction

Decades of research into cognitive and social aspects of learning have developed a clear picture of the importance of learners' active involvement in the expression, examination, and manipulation of their own knowledge, as well as the equal importance of guidance provided by social processes and mentorship. Recently these findings have been reflected in software technology for learning: systems are now providing learners with the means to construct and manipulate their own solutions while they are being guided by the software and interacting with other learners. My work is within this spirit, providing representational tools in support of collaborative learning. *Representational tools* may range from basic office tools such as spreadsheets and outliners to "knowledge mapping" software. Such tools help learners see patterns, express abstractions in concrete form, and discover new relationships [4, 8]. These tools can function as *cognitive* tools that lead learners into certain knowledge-building interactions [3, 7].

For a number of years, my colleagues and I have been building, testing, and refining a diagrammatic environment ("Belvedere") intended to support secondary school children's learning of critical inquiry skills in the context of science. The diagrams were first designed to capture scientific argumentation, and later simplified to focus on evidential relations between data and hypotheses. This change was driven in part by a refocus on *collaborative* learning, which led to a major change in how we viewed the role of the interface representations. Rather than viewing the representations as medium of communication or a formal record of the argumentation process, we came to view them as resources (stimuli and guides) for conversation [12, 17]. Meanwhile, various projects with similar goals (i.e., critical inquiry in a collaborative learning context) were using radically different representational systems, such as hypertext/hypermedia [6, 9, 13, 22]; node-link graphs representing rhetorical, logical, or evidential relationships between assertions [11, 14, 19, 20] containment [1], and evidence or criteria matrices [10].

Both empirical and theoretical inquiry suggests that the expressive constraints imposed by a representation and the information (or lack thereof) that it makes salient may have important effects on students' discourse during collaborative learning. Specifically, as learner-constructed external representations become part of the collaborators' shared context, the distinctions and relationships made salient by these representations may influence their interactions in ways that influence learning outcomes. However, to date little systematic research has undertaken to explore possible effects of this variable on collaborative learning, except for [5].

This paper motivates and describes our research and reports initial results from such a study.

2 Representational Guidance

The major hypothesis resulting of this work is that variation in features of representational tools used by learners working in small groups can have a significant effect on the learners' knowledge-building discourse and on learning outcomes. The claim is not merely that learners will talk about features of the software tool being used. Rather, with proper design of representational tools, this effect will be observable in terms of learners' talk about and use of *subject matter concepts and skills*. We have begun investigations to determine what features have what kind of effect. This section develops an initial theory of how representations guide learning interactions, and applies this analysis to make specific predictions concerning the effects of selected features of representational tools. The discussion begins with some definitions.

Representational *tools* are software interfaces in which users construct, examine, and manipulate external representations of their knowledge. Our work is concerned with symbolic as opposed to analogical representations. A notation/artifact distinction [16] is critical to the theory, as depicted in Figure 1. A representational tool is a software implementation of a representational *notation* that provides a set of primitive elements out of which representations can be constructed. (For example, in Figure 1, the representational notation is the collection of primitives for making hypothesis and data statements and "+" and "-" links, along with rules for their use.) The software developer chooses the representational notation and instantiates it as a representational tool, while the user of the tool constructs particular representational *artifacts* in the tool. (For example, in Figure 1 the representational artifact is the particular diagram of evidence for competing explanations of mass extinctions.)

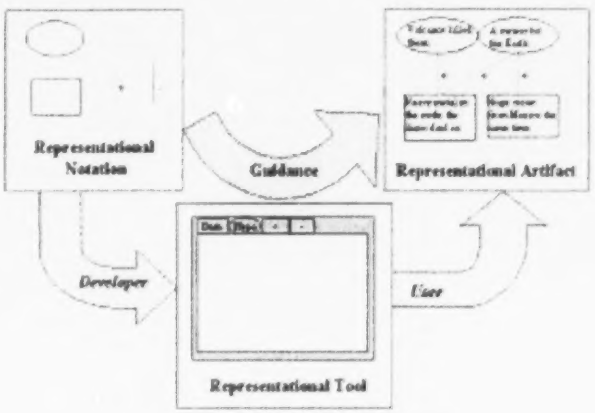


Figure 1 Representational Guidance

Learning interactions include interactions between learners and the representations, between learners and other learners, and between learners and mentors such as teachers or pedagogical software agents. Our work focuses on interactions between learners and other learners, specifically verbal and gestural interactions termed collaborative learning discourse.

Each given representational notation manifests a particular representational guidance, expressing certain aspects of one's knowledge better than others do. The concept of representational guidance is borrowed from artificial intelligence, where it is called *representational bias* [21]. The phrase *guidance* is adopted here to avoid the negative connotation of *bias*. The phrase knowledge unit will be used to refer generically to components of knowledge one might wish to represent, such as hypotheses, statements of fact, concepts, relationships, rules, etc. Representational guidance manifests in two major ways:

- *Constraints*: limits on expressiveness, i.e., which knowledge units can be expressed [15].
- *Salience:* how the representation facilitates processing of certain knowledge units, possibly at the expense of others [8].

As depicted in Figure 1, representational guidance originates in the notation, but affects the user through both the tool and artifacts constructed in the tool.

The core idea of the theory may now be stated as follows: Representational tools mediate collaborative learning interactions by providing learners with the means to articulate emerging knowledge in a persistent medium, inspectable by all participants, where the knowledge then becomes part of the shared context. Representational guidance constrains which knowledge can be expressed in the shared context, and makes some of that knowledge more salient and hence a likely topic of discussion. The discussion now turns to three predictions based on differences between representational notations.

2.1 Representational notations bias learners towards particular ontologies

The first hypothesis claims that important guidance for learning interactions comes from ways in which a representational notation *limits* what can be represented [15, 21]. A representational notation provides a set of primitive elements out of which representational artifacts are constructed. These primitive elements constitute an ontology of categories and structures for organizing the task domain. Learners will see their task in part as one of making acceptable representational artifacts out of these primitives. Thus, they will search for possible new instances of the primitive elements, and hence (according to this hypothesis) will be guided to think about the task domain in terms of the underlying ontology.

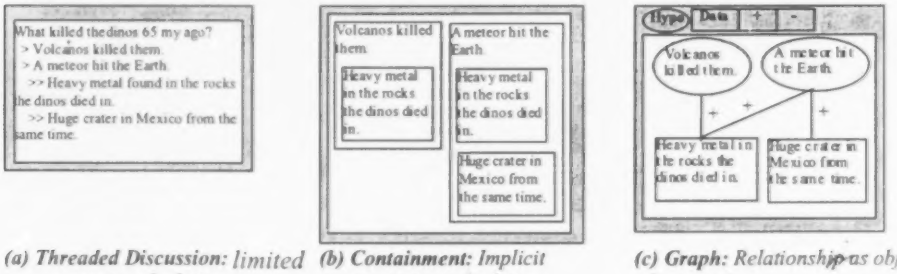
For example, consider the following interaction in which students were working with a version of Belvedere that required all statements to be categorized as either *data* or *claim*. Belvedere is an "evidence mapping" tool developed under the direction of Alan Lesgold and myself while I was at the University of Pittsburgh [18, 19, 20]. The example is from videotape of students in a 10th grade science class.

S1: So data, right? This would be data.
S2: I think so.
S1: Or a claim. I don't know if it would be claim or data.
S2: Claim. They have no real hard evidence. Go ahead, claim. I mean who cares? Who cares what they say? Claim.

The choice forced by the tool led to a peer-coaching interaction on a distinction that was critically important for how they subsequently handled the statement. The last comment of S2 shows that the relevant epistemological concepts were being discussed, not merely which toolbar icon to press or which representational shape to use.

2.2 Salient knowledge units are elaborated

This hypothesis states that learners will be more likely to attend to, and hence elaborate on, the knowledge units that are perceptually salient in their shared representational workspace than those that are either not salient or for which a representational proxy has not been created. The visual presence of the knowledge unit in the shared representational context serves as a reminder of its existence and any work that may need to be done with it. Also, it is easier to refer to a knowledge unit that has a visual manifestation, so learners will find it easier to express their subsequent thoughts about this unit than about those that require complex verbal descriptions [2]. These claims apply to any visually shared representations. However, to the extent that two representational notations differ in kinds of knowledge units they make salient, these functions of *reminding* and *ease of reference* will encourage elaboration on different kinds of knowledge units.


What killed the dinos 65 my ago?
> Volcanos killed them.
> A meteor hit the Earth.
>> Heavy metal found in the rocks the dinos died in.
>> Huge crater in Mexico from the same time.
Volcanos killed them.
A meteor hit the Earth.
Heavy metal in the rocks the dinos died in.
Heavy metal in the rocks the dinos died in.
Huge crater in Mexico from the same time.
Hypo
Data
+
-
Volcanos killed them.
A meteor hit the Earth.
Heavy metal in the rocks the dinos died in.
Huge crater in Mexico from the same time.

(a) Threaded Discussion: *limited representation of relation.*

(b) Containment: *Implicit representation of relations.*

(c) Graph: *Relationship as object of perception.*

Figure 2. Example of Elaboration Hypothesis

For example, consider the three representations of a relationship between four statements shown in Figure 2. The relationship is one of evidential support. The middle notation uses an implicit device, containment, to represent evidential support, while the right-hand notation uses an explicit device, an arc. It becomes easier to perceive and refer to the *relationship* as an object in its own right as one moves from left to right in the figure. Hence the present hypothesis claims that relationships will receive more elaboration in the rightmost representational notation.

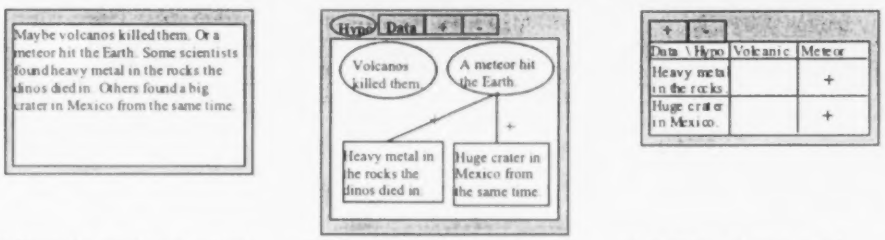
The opposite prediction is also plausible. Learners may see their task as one of putting knowledge units "in

their place" in the representational environment. For example (according to this competing hypothesis), once a datum is placed in the appropriate hypothesis container (Figure 2b) or connected to a hypothesis (Figure2c), learners may feel it can be safely ignored as they move on to other units not yet placed or connected. Hence they will not elaborate on represented units. This suggests the importance of making missing information salient.

2.3 Salience of missing units guides search

Some representational notations provide structures for organizing knowledge units, in addition to primitives for construction of individual knowledge units. Unfilled "fields" in these organizing structures, if perceptually salient, can make missing knowledge units as salient as those that are present. If the representational notation provides structures with predetermined fields that need to be filled with knowledge units, the present hypothesis predicts that learners will try to fill these fields.

For example, Figure 3 shows artifacts from three notations that differ in salience of missing evidential relationships. In the textual representation, no particular relationships are salient as missing: no particular prediction about search for new knowledge units can be made. In the graph representation, the lack of connectivity of the volcanic hypothesis to the rest of the graph is salient. Hence this hypothesis predicts that learners will discuss its possible relationships to other statements. However, once some connection is made to the hypothesis, it will appear connected, so no further relationships will be sought. In the matrix representation, all undetermined relationships are salient as empty cells. The present hypothesis predicts that learners will be more likely to discuss many relationships between statements when using matrices.


Maybe volcanos killed them. Or a meteor hit the Earth. Some scientists found heavy metal in the rocks the dinos died in. Others found a big crater in Mexico from the same time.
Hypo
Data
Volcanos killed them.
A meteor hit the Earth.
Heavy metal in the rocks the dinos died in.
Huge crater in Mexico from the same time.
Data \ Hypo
Volcanic
Meteor
Heavy metal in the rocks.
Huge crater in Mexico.
+
+

(a) Text: *No relation is saliently missing.*

(b) Graph: *Partial salience of missing relations.*

(c) Matrix: *Salience of all missing relations.*

Figure 3. Example of Salient Absence Hypothesis

2.4 Predicted Differences

Based on the discussion of this section, the following predictions were tested in the study reported below. The symbol ">" indicates that the discourse phenomenon at the beginning of the list (concept use, elaboration, or search) will occur at a significantly greater rate in the treatment condition(s) on the left of the symbol than in those on the right

Concept Use: {Graph, Matrix} > {Container, Text, Threaded Discussion}. The Graph and Matrix representations *require* that one categorize statements and relations. This will initiate discussion of the proper choice, possibly including peer coaching on the underlying concepts. The Container, Text, and Threaded Discussion representations provide only implicit categorization. Students may discuss placement of information, but this talk is less likely to be expressed in terms of the underlying concepts.

Search for Missing Relations: Matrix > {Container, Graph} > {Text, Threaded Discussion}. The matrix representation provides an empty field for *every* undetermined relationship, prompting participants to consider all of them. In Graphs or the Container representations, salience of the lack of *some* relationship disappears as soon as a link is drawn to the statement in question or another is placed in its container, respectively. Threaded Discussion does not specifically direct searches toward missing relationships.

The Elaboration hypothesis was not tested independently of the Search hypothesis in this study.

3 An Initial Study

This section reports on an initial study that was conducted to identify trends suggesting that there is a phenomenon worthy of further study; and to refine analytic techniques. Specifically, the study examined how the amount of talk about evidence and the amount of talk about the epistemological status of propositions (empirical versus theoretical) differed across three representational tools, and provided qualitative observations to guide further study.

3.1 Design

Six pairs (twelve participants) were distributed evenly between three treatment conditions in a simple between-subjects design. The three treatment conditions corresponded to three notations: Text, Graph, and Matrix. These notations differ on more than one feature, such as ontology, whether inconsistency relations are represented, and visual and textual notations. I intentionally chose this research strategy (instead of manipulating precisely one feature at a time) in order to maximize the opportunity to explore the large space of representations within the time scale on which collaborative technology is being adapted.

3.2 Method

3.2.1 Participants

Middle-school boys were recruited by my assistant (Cynthia Liefeld) from soccer practice. Two pairs of participants were run in each of the three conditions. Each pair consisted of boys who knew each other, a requirement intended to minimize negotiation of a new interpersonal relationship as a complicating factor.

3.2.2 Materials

Software. Three existing software packages were used: Microsoft Word (Text), Microsoft Excel (Matrix), and Belvedere (Graph). Groups using MS Word were not prohibited from using its typographical devices such as different typefaces, styles, lists, etc. We did not restrict participants' appropriation of typographical devices for organizing information, but neither did we encourage any particular use of the textual medium. Groups using MS Excel were provided with a prepared matrix that had the labels "Hypotheses" and "Data" in the upper left corner, and cells formatted sufficiently large to allow entry of textual summaries of the same. Participants were specifically told to enter hypotheses as column headers, data as row headers, and to record the relationships in the internal cells. The Graph condition used Belvedere. The version of Belvedere used (2.1) provides rounded nodes for hypotheses, rectangles for data, and links for consistency and inconsistency relations between them. Hypothesis and data shapes are filled with textual summaries of the corresponding claims.

Science Challenge Problems. Participants were presented with "science challenge problems" in a web-browser. A science challenge problem presents a phenomenon to be explained (e.g., determining the cause of the dinosaur extinctions, or of a mysterious disease on Guam known as Guam PD), along with indices to relevant resources. For example, one can obtain lists of articles posing possible explanations of the phenomenon, reporting empirical findings from fieldwork or laboratory work, or explaining basic domain concepts. These are relatively ill-structured problems: at any given point many possible knowledge units may reasonably be considered. The materials we used were modified from the classroom versions of science challenge problems developed by Arlene Weiner and Eva Toth.[1] The experimental version excluded hands-on activities, links to external sites and activity guide.

[1] Available at http://lilt.ics.hawaii.edu/belvedere/materials/index.html.

Computer Setup. The computer screen was divided in half as shown in Figure 4. The left-hand side contained the representational tool -- any one of Text, Graph (shown), or Matrix. The right hand side contained a web browser open to the entry page for the science challenge materials.

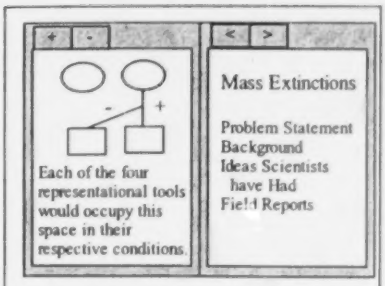


Figure 4. Screen Layout for Studies

3.2.3 Procedure

Participants were seated in front of a single monitor and keyboard. After an introduction to the study and signing of permission forms, participants were shown the software and allowed to practice the basic manipulations such as creating and linking nodes or filling in matrix cells. This training did not involve any mention of concepts of evidence or of the problem domain.

Participants were then presented with the problem statement in the web browser on the right. The problem solving session was initiated when they were instructed to identify hypotheses that provide candidate explanations of the phenomenon posed, and to evaluate these hypotheses on the basis of laboratory studies and field reports obtained through the hypertext interface. They were instructed to use the representational tool during the problem solving session to record the information they find and explore how it bears on the problem. Participants were responsible for deciding how to share or divide use of the keyboard and mouse. The procedure described in this paragraph was repeated, first with a "warm-up" problem, and then with the problem for which data is reported below (Guam PD). Sessions were videotaped with the camera pointed at the screen over the shoulder of one of the participants.

3.3 Results

Analysis was based primarily on coding of transcripts of participants' spoken discourse, and secondarily on participants' representational artifacts.

3.3.1 Coding and Analysis of Discourse

Pilot study videotapes from the six one-hour problem-solving sessions were transcribed and segmented. A segment was defined to be a modification to the external representation or a single speaker's turn in the dialogue, except that turns that expressed multiple propositions were broken into multiple segments. Segments were coded using the QSR Nud*ist software package.

The following codes provide the dependent variables of interest. *Epistemological Classification* codes discourse about the epistemological status of a statement, including classification as empirical (e.g., "that's data"), theoretical (e.g., "that's a hypothesis, isn't it?") or discussion of the choice (e.g., "do you want me to go data or hypothesis?"). In the present study we only wanted to see whether the tools differed in their prompting for making this choice, so did not discriminate these subcategories. Sub-dimension *Evidential Relation* is applied to segments where participants discuss or identify the nature of the evidential relationship between two statements. The codes are *Consistency* (e.g., "it's also for," "that confirms"), *Inconsistency* ("so that's against," "with this one, no, conflicts, right?"), or *Equivocal*, applied when participants raise the question of which relationship holds, if any, without identifying one specifically ("is that for or against?," "it can neither confirm nor deny"). In some cases, evidential relationships were apparently being expressed in terms of the representational primitives provided by the software (e.g., "connect these two"). These utterances were also coded with the appropriate Evidential Relation category, but marked with the Level code (discussed below) so that such "tool-level talk" could be distinguished during the analysis. Topic sub-dimension *Other Topic* codes segments not coded as one of the above topics. The "other" codes include *On-task* (e.g., "are we done with this?"), *Off-task* (e.g., "what's for lunch?"), or *Unclassifiable* (e.g., "uh," mumbles, etc.).

The remaining coding dimensions are used to select out relevant segments for particular analyses. *Mode* indicates whether the segment is coded for its *Verbal* content or for an action taken on the *Representational* artifact. The final two dimensions only apply to verbal segments. *Level* is applied only to Epistemological and Evidential Verbal segments, and indicates whether an utterance made direct use of epistemological or evidential concepts (e.g., "supports," "hypothesis": *Conceptual*) or was expressed in terms of the software

(e.g., "link to this," "round box": *Tool-based*). *Ownership* indicates whether the participant was merely reading text that we provided (Recited) or expressing their own ideas (Non-Recited).

Coding was performed by two of my assistants (Chris Hundhausen and Laura Girardeau). Questions of interpretation, problematic segments, etc. were discussed among the three of us during meetings, but the coding itself was done independently. Inter-rater reliability was computed using the Kappa statistic across all of the categories described above, producing a value of 0.92 (n=1942).

Table 1. Summary of Verbal Coding

Verbal segments tested: nesting indicates subset selection; % are of "Not Off-Task"	Text		Graph		Matrix	
	N	*%*	*N*	*%*	*N*	*%*
Non-Recited	778	*n/a*	626	*n/a*	537	*n/a*
..Not Off-Task	694	100	613	100	508	100
....Evidential Relation	4	0.58	32	5.22	100	19.69
......Consistency	3	0.43	21	3.43	54	10.63
......Inconsistency	1	0.14	6	0.98	35	6.89
......Equivocal Evidential	0	0.00	5	0.82	11	2.17
......Conceptual	3	0.4	9	1.47	43	8.46
......Tool-Based	1	0.1	23	3.75	57	11.22
....Epistemological Classification	39	5.62	57	9.30	36	7.09
......Conceptual	19	2.74	33	5.38	7	1.38
......Tool-Based	20	2.88	24	3.92	29	5.71

Selected results of coding are shown in Table 1, focusing on segments coded as Mode=Verbal, and showing both counts and percentages for each of the three treatment groups. Percentages are taken relative to Non-Recited on task utterances, shown in the second row. Counts and percentages for Evidential Relation are broken down in two orthogonal ways: by whether the relation was Consistency, Inconsistency, or Equivocal; and by whether the talk about evidence was Conceptual or Tool-Based. Epistemological Classification was broken down by Conceptual or Tool-Based. Due to the small sample size we did not perform statistical testing in this preliminary study.

3.3.2 Qualitative observations

The document created by one Text group contained no expression of evidential relations, and the transcript of verbal discourse for this group contained no overt discussion of evidential relations. All of the discussion of evidence in Text occurred in the other group at the end of the session (the longest session in the pilot study), at which time they also added several expressions of evidential relations. A document produced by one of the Graph groups is notably linear, in spite of the fact that Graph is normally considered a nonlinear medium. A pattern of *identify information, categorize information, add it to the diagram, link it in* is typical of interactions in this transcript. This pattern of activity, which leads to the linearity of the graph, is consistent with the competitor to the Elaboration hypothesis: participants may feel that the primary task is to connect each new statement to something else, after which it can be ignored. Finally, the Matrix artifacts were especially striking because participants were not specifically instructed to fill in all the cells, yet they did so. The transcripts illustrated participants' systematic identification of evidential relations as they worked down the columns, and in one case their appropriate use of the table to rule out a hypothesis that they had proposed.

3.4 Discussion

Recall that the Search hypothesis predicts that participants will be more likely to seek evidential relations when using representations that prompt for these relations with empty structure (Text < Graph < Matrix). The row labeled "Evidential Relation" is relevant to the Search hypothesis. This row counts, for each treatment group, the percentage of verbal segments that were coded with any one of the three evidential values (Consistent, Inconsistent, Choice). The results appear to be consistent with the Search hypothesis: Text=0.58% < Graph=5.22% < Matrix=19.69%. This trend holds even when limited to Conceptual expressions of evidential relations: Text=0.43% < Graph=1.47% < Matrix=8.48%. Note however that a substantial portion of talk about evidence in the Graph and Matrix conditions is tool based (about two-thirds

of Graph and half of Matrix evidential utterances are tool-based). This is as expected, since these tools, unlike Text, provide objects that may be referred to as proxies for evidential relations.

The breakdown of Evidential talk according to the type of relation shows the influence of the exhaustive prompting of Matrix. In Text and Graph, participants focused primarily on Consistency relations, a possible manifestation of the confirmation bias. Treatment was more balanced in Matrix, with almost half of the talk about evidential relations being concerned with inconsistency or equivocal relations. This may be because Matrix prompts for consideration of relationships between all pairs of items: participants are more likely to encounter inconsistency or indeterminate relations when considering those they may have neglected in the Graph or Text conditions.

Addressing the Concept Use hypothesis, we found that 5.62% of Text, 7.09% of Matrix and 9.30% of Graph utterances were concerned with the classification of new information as *data* versus *hypothesis* or their equivalents. We believe that Text would have been lower, except that the instructions for all three conditions directed participants to consider and record hypotheses and empirical evidence. Text participants, like others, complied with these instructions, for example, by labeling propositions as "Data" or Hypothesis." Graph's greater proportion of epistemological classification talk is explained by its most explicit use of visually distinct shapes to represent data and hypotheses.

4 Conclusions

Overall, the results are encouraging with respect to the question of whether there is a phenomenon worth investigating. Differences in the predicted directions were seen in both talk about evidence and about the epistemological status of statements. However, this sample data cannot be taken as conclusive. Caveats, all of which are being addressed by ongoing work, include the small sample size (hence no test of significance), the lack of a learning outcomes measure, and the need for a more direct test of the claim that representational state affects subsequent discourse processes. Furthermore, analyses based on frequencies of utterances across the session as a whole fail to distinguish utterances seeking evidential relations from those elaborating on previous ones (i.e., between the Search and Elaborate hypotheses), or to show a causal relationship between the state of the representation and the subsequent discourse. A more sophisticated coding is required to test whether the representation or salient absence of a particular (kind of) knowledge unit influences search for or elaboration on that unit. All of these deficiencies are being addressed in a study underway at this writing. Pending the results of this study, plans for future work include attempts to replicate selected results in distance learning situations, both synchronous and asynchronous. This line of work promises to inform the design of future software learning environments and to provide a better theoretical understanding of the role of representational guidance in guiding learning processes.

References

1. Bell, P. (1997, December). Using argument representations to make thinking visible for individuals and groups. In Proceedings of the Computer Supported Collaborative Learning Conference '97, 10-19. University of Toronto.
2. Clark, H.H. & Brennan, S.E. (1991). Grounding in Communication. In L.B. Resnick, J.M. Levine and S.D. Teasley (Eds.), Perspectives on socially shared cognition (pp. 127-149). American Psychological Association.
3. Collins, A. & Ferguson, W. (1993). Epistemic forms and epistemic games: Structures and strategies to guide inquiry. Educational Psychologist, 28(1): 25-42.
4. Goldenberg, E. P. (1995). Multiple Representations: A Vehicle for Understanding Understanding. In D. Perkins, J. Schwartz, M. West, & M. Wiske (Eds.), Software goes to school: Teaching for understanding with new technologies (pp. 155-171). New York: Oxford University Press.
5. Guzdial, M. (1997, December). Information ecology of collaborations in educational settings: Influence of tool. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 91-100). Toronto.
6. Guzdial, M., Hmelo, C., Hubscher, R., Nagel, K., Newstetter, W., Puntambekar, S., Shabo, A., Turns, J., & Kolodner, J. L. (1997, December). Integrating and guiding collaboration: Lessons learned in computer-supported collaborative learning research at Georgia Tech. In Proceedings of the 2nd

International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 91-100). Toronto.

7. Lajoie, S. P., & Derry, S. J. (Eds.). (1993). Computers as Cognitive Tools. Hillsdale, NJ: Lawrence Erlbaum Associates.
8. Larkin, J. H. & Simon, H. A. (1987). Why a diagram is (sometimes) worth ten thousand words. Cognitive Science 11(1): 65-99. 1987.
9. O'Neill, D. K., & Gomez, L. M. (1994).The collaboratory notebook: A distributed knowledge-building environment for project-enhanced learning. In Proceedings of Ed-Media '94, Vancouver, BC.
10. Puntambekar, S., Nagel, K., Hübscher, R., Guzdial, M., & Kolodner, J. (1997, December). Intra-group and intergroup: An exploration of learning with complementary collaboration tools. In Proceedings of the Computer Supported Collaborative Learning Conference '97 (pp. 207-214). University of Toronto.
11. Ranney, M., Schank, P., & Diehl, C. (1995). Competence versus performance in critical reasoning: Reducing the gap by using Convince Me. Psychology Teaching Review 4(2).
12. Roschelle, J. (1994, May). Designing for cognitive communication: Epistemic fidelity or mediating collaborative inquiry? The Arachnet Electronic Journal of Virtual Culture.
13. Scardamalia, M., Bereiter, C., Brett, C., Burtis, P.J., Calhoun, C., & Smith Lea, N. (1992). Educational applications of a networked communal database. Interactive Learning Environments, 2(1), 45-71.
14. Smolensky, P., Fox, B., King, R., & Lewis, C. (1987). Computer-aided reasoned discourse, or, how to argue with a computer. In R. Guindon (Ed.), Cognitive science and its applications for human-computer interaction (pp. 109-162). Hillsdale, NJ: Erlbaum.
15. Stenning, K. & Oberlander, J. (1995). A cognitive theory of graphical and linguistic reasoning: Logic and implementation. Cognitive Science 19(1): 97-140. 1995.
16. Stenning, K. & Yule, P. (1997). Image and language in human reasoning: A syllogistic illustration. Cognitive Psychology 34: 109-159.
17. Suthers, D. (unpublished). Designing for Internal vs. External Discourse in Groupware for Developing Critical Discussion Skills. Presented at the CHI95 Research Symposium, May 6-7. 1995, Denver CO. Available: http://lilt.ics.hawaii.edu/lilt/papers/chi95learning.ps
18. Suthers, D. & Jones, D. (1997, August). An architecture for intelligent collaborative educational systems. Paper presented at AI-Ed 97, the 8th World Conference on Artificial Intelligence in Education, Kobe.
19. Suthers, D., Toth, E., and Weiner, A. (1997, December). An integrated approach to implementing collaborative inquiry in the classroom. In Proceedings of the 2nd International Conference on Computer Supported Collaborative Learning (CSCL'97) (pp. 272-279). Toronto.
20. Suthers, D. and Weiner, A. (1995, October). Groupware for developing critical discussion skills. Paper presented at CSCL '95, Computer Supported Cooperative Learning, Bloomington, Indiana.
21. Utgoff, P. (1986). Shift of bias for inductive concept learning. In R. Michalski, J. Carbonell, T. Mitchell (Eds.) Machine Learning: An Artitificial Intelligence Approach, Volume II (pp. 107-148). Los Altos: Morgan Kaufmann.
22. Wan, D., & Johnson, P. M. (1994, October). Experiences with CLARE: a Computer-Supported Collaborative Learning Environment. International Journal of Human-Computer Studies.

Learning from the Learning of other Students

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This paper concerns the use of dialogues in student learning and how such dialogues can be captured for subsequent use by other learners. The process of learning by observing another person's learning is known as vicarious learning. The paper begins by discussing the movement towards more flexible types of learning and the belief by many that traditional dialogue has been omitted from a lot of today's courseware. Dialogue can be considered as one of the stages in the learning cycle and to support it there is a need to create tertiary courseware, this being the third stage in the cycle. Some of the research that has taken place into vicarious learning is described and this has shown that it has some benefit to learning and also produces positive feelings in students of being part of a learning community. Finally the vicarious learning resources that have been produced within a software development course at Edith Cowan university using a dynamic screen capturing tool are discussed together with a possible dissemination system.

Keywords: **Distance Education, Flexible learning, Vicarious Learning, Programming**

1 Introduction

Universities and colleges today have record numbers of students and yet the cost being spent per student is steadily decreasing as budgets are cut and universities become ever more competitive. One of the consequences of this is that many managers are turning to the Internet as a means for delivering courseware to students in a supposedly cost-effective manner. Students are also demanding more flexible learning with learners being able to learn when they want (frequency, timing, duration), how they want (modes of learning), and what they want (that is learners can define what constitutes learning to them) [14].

The situation has therefore arisen that students spend more time away from a traditional campus and technology is being used to provide the necessary flexibility with computer networking empowering connectivity and communication, allowing synchronous and asynchronous one-to-one and one-to-many communication [13]. However, such technology does not necessarily support some of the learning situations that are necessary in higher education. Laurillard [6] points out that learning in many educational contexts, particularly in higher education, requires learning about descriptions of the world, knowledge derived from someone else's experience, and from understanding someone else's arguments. She states that:

> *We cannot claim to have sorted out once and for all what students need to be told if they are to make sense of topic X. No matter how much detailed research is done on the way the topic is conceptualised, the solution will not be found in new ways of putting it across. The new way of telling may sort out one difficulty, but it may well create others. All we can definitely claim is that there are different ways of conceptualising the topics we want to teach. So all we can definitely conclude is that teachers and students need to be aware of those differences and must have the means to resolve them.*

The main way this has been done in the past has been by students participating in dialogue with fellow students and their tutors. We do have email and synchronous "chat" available to support dialogue to some extent but it may well be argued that this is insufficient to support the above.

2 The Learning Cycle

Dialogue can be considered as a crucial part of the learning cycle [9]. The cycle is shown in figure 1.

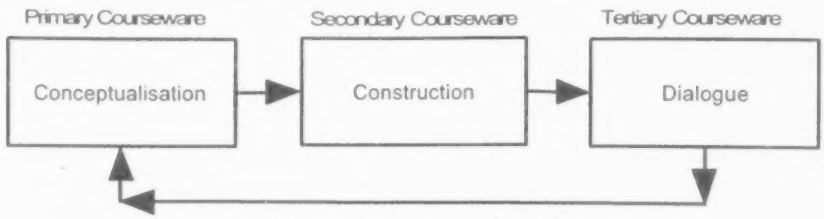

Figure 1: The learning Cycle

It can be considered to comprise:

- conceptualisation which comes from interacting with the primary content and relates to a learner's current state of understanding.
- construction and the use of knowledge occurs with the use of secondary courseware tools such as concept mappers. It involves picking out particularly relevant material, putting the information together in ways which have meaning for the learner, and relating old and new material into a coherent whole.
- dialogue which involves the testing of understanding and can possibly be facilitated with tertiary courseware.

Mayes et al [9] suggest that the third section of the learning cycle, dialogue, can itself be broken up into three stages, these being discussion, reflection and reification. Mayes et al agree with Laurillard that discussion is fundamental to effective education and that a deep understanding is promoted far more effectively and efficiently during discussions. Reflection has always been thought to be an important aspect of learning and can be considered as the testing of new knowledge against the schemata that hold our existing knowledge. And finally reification is a term put forward by Mayes et al and concerns the structuring of newly acquired knowledge into a new object of thought integrated with other knowledge.

The question then arises as to what sort of tertiary courseware can be produced and utilised to support the dialogue aspect of the learning cycle bearing in mind that the material will have to be used in flexible learning environments. One particularly interesting line of research has been into recording of discussions and making them available to other students in a flexible mode. This concept is known as vicarious learning where this is defined as [2]:

> *The potential benefit to learners of being able to observe or 'listen in' on experts or their peers as they discuss a new topic.*

The following can be considered to be vicarious resources:

- Frequently asked questions (FAQs). Here students can learn from the answers to typical questions posed by other students.
- Listservers. These promote vicarious learning as students receive the text dialogues that take place between various subscribers. The term "lurker" is often used for the person who does not participate in dialogues but prefers to simply observe.
- Bulletin boards. These provide the means for asynchronous dialogues and again can be used by "lurkers".
- Chat rooms. These provide the means for synchronous dialogues.

3 Research into Vicarious Learning

Research initiatives are in two main areas, the first attempting to determine if vicarious learning is of benefit to students and the second looking at how such dialogues might be made available as tertiary courseware for re-use by other students.

There are several interesting questions that might be worthy of investigation in the first area. Cox et al [2] suggest that we need to determine who are useful models for the vicarious learner, experts or novices. It might be better to observe experts as skilled behaviour would hopefully be modelled in a clear way, although this is not of course always true as many experts find it difficult to make their knowledge explicit. It could be argued that student – student dialogues would be better to observe as the observing student would be better able to identify with other students. Also the students participating in the dialogue might use more appropriate language and also ask questions of each other that they may not have wished to ask their tutor. Cox et al also point out that observing unskilled behaviour may also prove to be of benefit as the observing student would determine from the dialogue what sort of errors to avoid without having to make those errors themselves. Also of course, the dialogue type to observe may depend on the type of student who is the observer. It might be more appropriate for a strong student to observe experts and for a weak student to observe novices.

In one particular piece of research on vicarious learning [7] benefits were found that were both cognitive, with an increase in knowledge and understanding in the particular curriculum area, and social with exposure to peer discussion creating positive feelings of being part of a learning community.

Lee et al [7] carried out research within an on-line Masters level course in Computers in Teaching and Learning. They created task-directed discussions (TDDs) in order to capture good learning dialogues amongst students and to overcome the "barriers of silence" that might otherwise occur. Over 30 hours of discussions among students, and between students and a tutor (the expert), using the TDDs were videoed.

An architecture called the Dissemination System (DS) was created from primary instructional materials and integrated clips taken from the videos. The DS allows a multimedia database of video and audio clips, text transcriptions, and annotated graphics to be integrated with primary expository teaching material and delivered via the Web. The system was then used in an experiment to investigate the vicarious resources in a controlled laboratory setting.

The experiment used a section of the course on Models of Learning with Technology. Two sets of learning materials were created, the first comprising primary learning materials (approximately 45 web pages) and the second comprising both primary learning materials and an integrated set of vicarious learning resources. The vicarious resources had been obtained from the videoed dialogues and comprised 108 video clips, 13 audio clips, 43 text transcriptions, and 27 audio annotated graphics. The resources were accessible by either clicking on highlighted keywords or by a search mechanism.

Two groups of students took part in the experiment, one using only the first set of learning materials whilst the other used the second set of learning materials which included the vicarious resources. The conclusions that Lee et al drew from the experiment were that there were some benefits in learning and substantial positive changes in attitudes and discussion behaviour for the students who used the vicarious learning resources. The researchers also make the point that although some people claim that learning can only take place when students are personally engaged in discussion, the evidence suggests that observing peer dialogues can, on the contrary, provide a useful source for learning, both cognitively and socially. The researchers have in fact suggested that such vicarious learning may sometimes be more beneficial than being a participant, depending on the state of the learner [11].

The web based materials used in the experiment are available at http://www.hcrc.ed.ac.uk/Vicar/TT/. They are fairly slow to download from the Web but realistically they could be put onto a CD ROM for use with distance learners. The audio dialogues that are available are played whilst a static graphical image is displayed to the learner. Such a dialogue concerns the graphic being displayed and I felt that something was lost in this type of dialogue and that it would have proved to be more useful and meaningful if objects on the graphic could have been "pointed to" in order to draw the observer's attention to the important aspects of the graphic.

4 Creation of Vicarious learning Resources with Dynamic Screen Capturing Tools

During the summer school of 1998 at Edith Cowan University, I made use of Lotus ScreenCam for student-tutor dialogues within a Software Development unit. Between lectures and laboratory sessions, students had

no contact with me as I was off campus, however I did have access to email at home enabling students to send me ScreenCam movies of any programming problems that they were having. In addition to movies, students would also send the programming code enabling me to use this when making a "reply" movie. An example of a screenshot taken from a movie, which was sent to me by a student, is shown in figure 2.

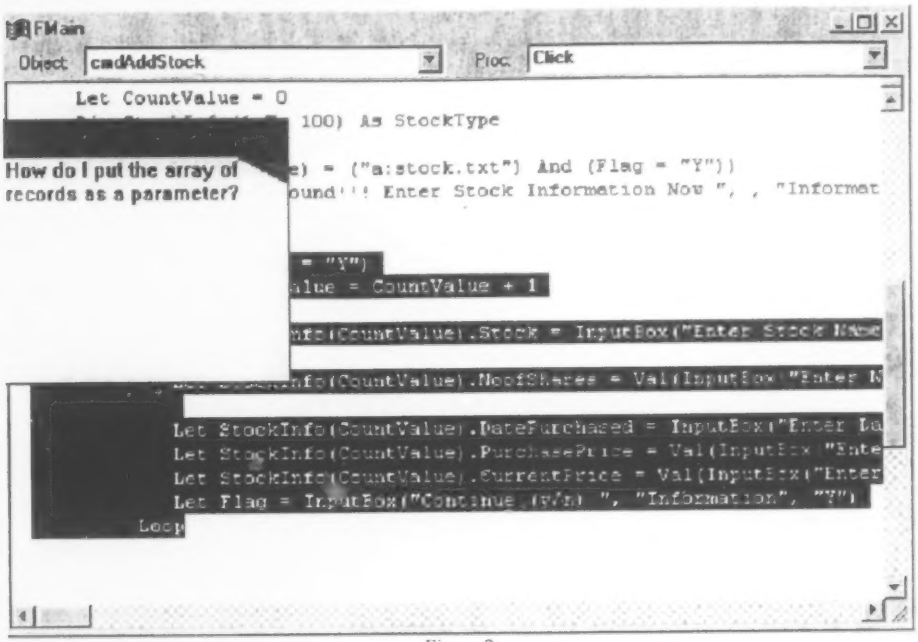

Figure 2

The movie had several text captions and concerned a problem that this student was having with passing arrays to subprograms in Visual BASIC. A screenshot taken from the movie, which I made and subsequently sent back to the student, is shown in figure 3.

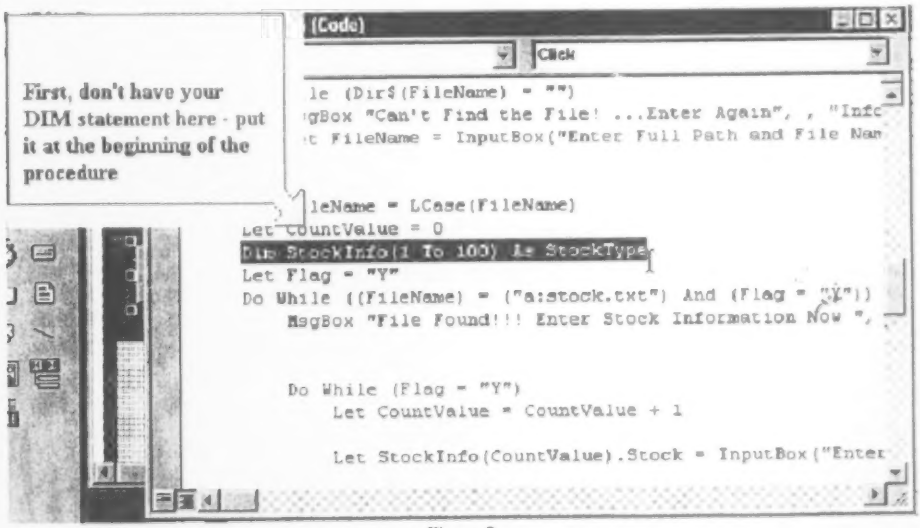
(Code)
Click
First, don't have your DIM statement here - put it at the beginning of the procedure
Dim StockInfo(1 To 100) As StockType
Let Flag = "Y"
Do While ((FileName) = ("a:stock.txt") And (Flag = "Y"))
MsgBox "File Found!!! Enter Stock Information Now ",
Do While (Flag = "Y")
Let CountValue = CountValue + 1
Let StockInfo(CountValue).Stock = InputBox("Enter

Figure 3

The screenshot in figure 3 includes a text caption that has nothing to do with the original student problem. It

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is the sort of comment that I would make if I were looking at the code that a student had produced in a laboratory session. In the rest of the movie, I was able to make suggestions on how to overcome the original problem and I also included a captioned comment about the lack of comments within the student's programming code. By using ScreenCam, I had been able to engage in a richer asynchronous dialogue with the student than I would otherwise have done by conventional means. In addition, as a side effect, I was building up vicarious learning resources for use in future semesters.

In addition to capturing asynchronous dialogues as described above, Lotus ScreenCam can be used to provide rich feedback to students on their assignment work. Simple "low-tech" audio tapes have been used in student feedback [1] and it is suggested that such feedback adds a social dimension to the commentaries with the tutor being able to talk personally to each student, whereas written comments lacked context and sounded impersonal.

I produced a set of such movies for the small group of campus-based students that were involved in the 1998 summer school session mentioned earlier. Each week the students attempted a small programming problem and handed in the relevant programming code together with a small text -captioned movie explaining their program. I then made a feedback movie for each student. Each feedback movie had audio commentaries to keep the production time to a minimum and the movies were placed onto ZIP disks that had been provided by the students. I was able to go through the programming code on the screen, highlighting areas of interest with the cursor whilst making comments and in addition run the student programs with a variety of data whilst passing comments about both the good and the bad points of the programs.

The sets of movies that the students handed in and that I produced have now become another vicarious learning resource for use by students in subsequent semesters. Each week, students are given a small programming problem to attempt and they can then use the movies to view the student – tutor interactions for a similar programming problem. In practice, students have commented on how useful they have found these resources. Feedback was elicited on-line and some of the comments follow:

- I found it helpful and interesting in giving clear visual instructions or explanations.
- All the other students solutions were very helpful. And they were informative.
- Only used the movies once, but they do provide a good resource for students experiencing difficulty.
- Pick up other students mistakes.
- Always forgot how to get to them
- Probably slack, but using the sound was too much hassle.

5 Delivery Mechanisms for Vicarious Resources

The last two student comments above indicate that there is a need for some form of technological delivery mechanism for the vicarious resources that have been produced that is simple and easy to use. Students need to be able to quickly find movies that are appropriate for the programming problem that they are attempting and then view the movie. We have experimented using the Web to deliver the movies however this has been a problem as movies with audio are of the order of 1MB in length per minute and take too long to download. Realistically it is necessary to make the movies available on CD ROM and we will be using a Windows Help file as a way of delivering the movies. There are several Help file authoring tool available and one that I have used extensively is ForeHelp [4]. A Help file can be produced with the usual contents and index pages with little effort and programs can be launched seamlessley thereby permitting the running of ScreenCam movies.

6 Discussion

It would appear that the use of vicarious learning resources by students can benefit learning and also provide positive feelings of being part of a learning community. However the creation of such resources needs to be done very carefully so that they are relevant and of interest to learners. If a synchronous dialogue is to be recorded by the use of video or audio then it is important to use task directed discussions [7] to ensure that a relevant dialogue ensues. Asynchronous dialogues usually take place by email or bulletin boards, however

they can be made richer if a dynamic screen capturing tool is used. Finally the vicarious learning resources that have been collected need to be made available to other learners and to this end Lee et al created a web based dissemination system. Another approach is to use a Windows Help file for disseminating such resources assuming that delivery is to be by Wintel hardware only.

In the future I intend to look at capturing synchronous dialogues using a dynamic screen capturing tool. These would be both student – student and student – tutor where the two participants sit in front of a PC whilst having a dialogue concerning a program that is being displayed.

References

[1] Anson, C. M. (1997). In Our Own Voices: Using Recorded Commentary to Respond to Writing. New Directions for Teaching and Learning, Spring 1997(69), 105-113.

[2] Cox, R., J. McKendree, et al. (1998). Learning vicariously from educational dialogue and discourse. 20th Annual Conference of the (US) Cognitive Science Society, Madison, Wisconsin.

[3] Domingue, J., & Mulholland, P. (1997). Teaching Programming at a Distance: The Internet Software Visualization Laboratory. Journal of Interactive Media in Education (http://www-jime.open.ac.uk), 1, 1-28.

[4] ForeHelp User' s Guide (1995). ForeFront Incorporated

[5] Garner, S. (1997). Cost Effective Multimedia Production for Frequently Updated Courseware. Paper presented at ASCILITE 97, Curtin University, Perth.

[6] Laurillard, D. (1993). Rethinking University Teaching: A Framework for the Effective use of Educational Technology, London Routledge.

[7] Lee, J., F. Dineen, et al. (1999). Vicarious Learning: cognitive and linguistic effects of observing peer dialogues. American Educational Research Association (AERA '99), Montreal, Quebec.

[8] Lotus Corporation. (1997). White Paper (Technical) http://www.lotus.com/home.nsf/welcome/screencam, (accessed on . une 23, 1999)

[9] Mayes, J., J. McKendree, et al. (1996). The Vicarious Learner: Rethinking the use of dialogue in teaching and learning, http://www.hcrc.ed.ac.uk/gal/vicar/VicarPapers/vicar.html (accessed on Aug 4, 2000).

[10] Mayes, J. T., & Neilson, I. (1996). Learning from other People's Dialogues: Questions about computer-based answers. In B. Collis & G. Davies (Eds.), Innovating Learning with Innovative Technology . Amsterdam: North-Holland.

[11] McKendree, J., K. Stenning, et al. (1998). "Why observing a dialogue may benefit learning." Journal of Computer Assisted Learning **14**: 110-119.

[12] Neville, L. (1995). Sense-making and Sensitivities: New Pedagogies? New Practices? New Acceptance of Old Ways of Learning? Australian Educational Computing (May 1995), 15-19.

[13] Nikolova, I. and B. Collis (1998). "Flexible learning and design of instruction." British Journal of Educational Technology **29**(Jan. '98): 59-72.

[14] Van den Brande L (1993). Flexible and distance learning John Wiley, Chichester, UK

Localization of a Feature Extraction Area for Touch-type Training Using a Camera

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This paper proposes a method to localize a feature extraction area for touch-type training using a camera. The feature extracted from pictures of a trainee's face is used for recognition of one's eye direction. The recognition of a trainee's eye direction enables us to give a trainee warnings and appropriate advice, and these warnings and advice assist a trainee to learn touch-typing quickly. The goal of this study is constructing a system which supports touch-type training using a camera. In this paper, a method to localize a feature extraction area using a horizontal direction's histogram and a vertical one mutually is proposed. These histograms are made from the sum of darkness values of pixels. Experimental results of the proposed method with trainees' black-and-white still pictures are described.

Keywords: **Touch-type training, Camera, Feature extraction, Histogram, Pattern recognition, Eye directions**

1 Introduction

In this paper, we propose a method which localizes a feature extraction area to recognize a trainee's eye direction for touch-type training. By the recognition of a trainee's eye direction using camera, it is possible to warn and give advice when a trainee looks at improper places. These warnings and advice must be effective for trainees to learn touch-typing quickly.

The capability of typing quickly is very helpful in studying and using IT (information technology). Nowadays the capability is becoming more and more important because many people use computers for calculating, writing, reading and so on, and the keyboard is the most common device to input characters. Users can type on a keyboard and train themselves in their own manner, because the keyboard is easy to use. However, typing in one's own manner has a speed limit which is much lower than typing in a proper manner. Furthermore, users' own training ways are not adaptable, that is, using their own typing style, the users would be able to type certain words or sentences quickly, but not so many.

Some training methods are proposed[1]-[3] for the purpose of learning touch-typing. Although the details of the methods vary, the methods have a common point. The point is that after a trainees roughly learn key positions, they should look at a display and should not look at a keyboard in order to learn touch-typing quickly.

The goal of this study is constructing a system which supports these touch-type training methods using a camera. The system warns and gives appropriate advice to a trainee automatically when one looks at improper places. In this paper, we deal with classification of eye directions into the following three classes: Looking at the display is the first class, looking at the keyboard is the second, looking at other places (not the display or the keyboard) is the third. Especially, in this paper, we propose a method to localize a feature extraction area for the classification using histograms of a trainee's face pictures. These histograms are made from the sum of darkness values of pixels.

2 Touch-type training system using a camera

2.1 Structure of the system

The supposed touch-type training system is as follows.
Hardware: A personal computer with a CCD camera.
Software: A touch-type training program and an eye direction recognition program

2.2 Process of an eye direction recognition program

Extracting an eye area from a picture of a trainee's head

Taking a picture of a trainee's head or the upper half of one's body using a camera which is placed on top of a display in the middle, and extracting an eye area from the picture.

Extracting features and classifying an eye direction

Extracting features from the picture of a trainee's eye area, then classifying the eye's direction into three classes.

Warning and advising

Warning with sound and giving appropriate advice when a trainee looks at improper places. Warnings concentrate one's attention on the training, and giving advice is effective for fast learning.

Some other research proposed methods on the process (1) and produced good results [4]. In this paper, we deal with the process (2) on the supposition that the process (1) is already done. To be applicable for most of touch-type training methods, the process (2) classifies eye directions into the following three classes: Looking at the display, the keyboard, other places (not the display or the keyboard).

3 Feature extraction and classification

Figure 1 shows vertical and horizontal histograms used for the classification of eye directions. The histograms are made from the sum of darkness values of pixels. Some research used the histograms, and reported that they are effective for the recognition of eye direction [5].

A vertical direction's histogram in an eye area has basically two peaks: the upper peak is the eyebrows; the lower one is the eyes. We expect those two peaks are key features for the recognition of eye direction, whether it be up or down.

On the other hand, a horizontal direction's histogram also has two peaks. Those peaks are expected to be key indicators for the recognition of eye direction, right and left.
In this study, a template matching method is used for the classification of eye directions using vertical and horizontal direction's histograms.

4 Localization of a feature extraction area

To obtain high classification rates, we must extract features from the area available for the classification, or reduce noise which is unavailable for the classification from a feature extraction area. For these purposes, we propose a method to localize an eye area.

4.1 Localization in a horizontal direction

Most vertical histograms have two peaks. The lower peak is basically at a line of the two eyes as shown in figure 2(a). Thus we localize an extraction area at the lower peak, and get a horizontal direction's histogram from the area as shown in figure 2(b). The histogram is expected to be a key feature for the recognition of right-and-left eye direction.

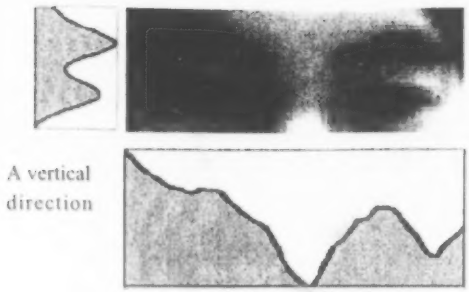
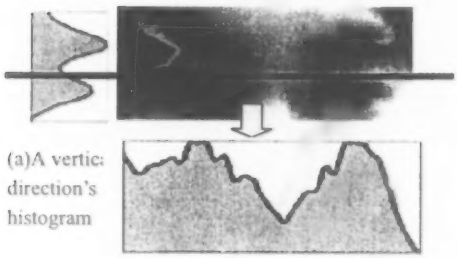


Figure 1. Histograms in an eye area.



(b) A localized horizontal direction's histogram

Figure 2. Localization in a horizontal direction.

4.2 Localization in a vertical direction

We localize a feature extraction area in a vertical direction using the localized horizontal direction's histogram (shown in figure 2(b)).

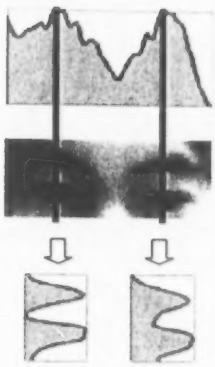
Peaks of the localized horizontal direction's histogram (shown in figure 3(a)) are basically at the two eyes (figure 2(b) is equal to figure 3(a)). Hence, we get vertical direction's histograms as shown in figure 3(b), using the horizontal direction's histogram as shown in figure 3(a). These histograms are expected to be key features for the recognition of up-and-down eye direction.

4.3 Experimental results

We made experiments to evaluate the proposed method of localization as follows:

- First, taking twenty-four still pictures of the trainees' heads (Three pictures were taken of each of eight trainees from each class(described in sect.1). The pictures were black-and-white, 256 picture elements and 72dpi.)
- Then, extracting an eye area by hand.
- Finally, localizing feature extraction areas as mentioned above.

Table 1 shows experimental results of localized areas by the proposed method. In table 1, the center of eye(s) means an iris in case an eyeball was shown in the picture, or the center of an eye's outline in case an eyeball was not shown in the picture.



(a)A localized horizontal direction's histogram (equal to fig.2(b))

(b)A localized vertical direction's histogram

Figure 3. Localization in a vertical direction.

A localized area	A horizontal direction	A vertical direction
the center of two eyes	2	10
the center of an eye	13	12
others	9	2

Table 1 Experimental results of localization

The reasons why the localized area was not at the center of two eyes are the following:
- 70% of the total were caused by inclined heads.
- 30% of the total were caused by noise such as glasses or hair.

5 Conclusions

In this paper, we propose a method to localize a feature extraction area using histograms for touch-type training. The feature is used for recognition of a trainee's eye direction.

Experimental results show the method has some problems when the following conditions exist: a head is inclined, noise such as hair or glasses are shown in the localized area.

To solve these problems, we have the following plans:
- Localization is carried out after adjusting inclined heads.
- Selecting one eye in case the localized area is at the center of only one eye.

References

[1] G. Ohiwa, "Keyboard Training for Information Education," IPSJ Technical Reports, Vol.CE-44-3, pp.11-18, 1997 (in Japanese).

[2] T. Masuda, "The method to master touch-typing in three hours," Nihon Keizai Shimbun, Inc., 1994 (in Japanese).

[3] T. Kawashima, "Method of touch-type training," Proceedings of 39th IPSJ Conference., 4Y-8, 1988 (in Japanese).

[4] M. Kosugi, "Human-face search and location in a scene by multi-pyramid architecture for personal identification," IEICE Transaction on information & systems., Vol.J77-D- II, No.4, pp.672-681, 1994 (in Japanese).

[5] T. Matsumoto, T. Ezoe, K. Wakaki, B. Mallinson, "A Method for the Objective Assessment of Learning Concentration in Computer Aided Instruction", Proceedings of ICCE99, pp.918-919, 1999.

Present State and Future Direction of Woman Informatization Education in Korea

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An informatization society, where high added value can be created through networks is different from an Industrial society where physical labor predisposes discrimination between men and women. As knowledge and information are regarded as the most important resources in an Informatization society, intelligence and emotional ability are given more importance than physical superiority. In light of this, the roles and positions of women are being newly evaluated, and the direction of the women's informatization movement has emerged as a new topic of the era. Korea places a strong emphasis on education and the percentage of women who attend University is also high. Contrary to this, the percentage of highly educated women who become working members of society is very low. These days, this problem has been recognized and education in woman informatization has actively proceeded. Taking various kinds of women's organization as the principal axis, woman informatization projects are actively unfolding. Government has also explored supporting plans in various aspects. This study explores the present state of women's informatization education and it's future direction.

Keywords: **Woman Education, Informatization Education**

1 Introduction

An Informatization Society is expected to be the 3F era: Female, Feeling, and Fiction. Productivity of culture and emotions is more important than labor productivity. Instead of labor productivity, sensitivity and intuition unique to women are expected to contribute a lot to the development of an emotional business that has high added value.

As the roles and position of women are newly evaluated, the direction of the women's informatization movement is emerging as an important topic. As it becomes necessary to have women's informatization education in Korea, a new movement has emerged. In light of this, this study will explore the present state and future direction of informatization education of women in Korea.

2 Present State and Problems of Woman Informatization Education in Korea

The studies on women and the informatization society have been introduced in Korea since the end of 1980. Until now, works on the development of women in an informatization society have been produced intermittently. The Korean Women's Association and National Women's Convention has dealt with "Woman and Informatization Society," and attracted the attention of the society of women overall. However, systematic, continuous and comprehensive studies on women and informatization have been insufficient. Also insufficient are the studies on the concrete policy alternatives for informatizing all women in accordance with national informatization.

2.1 Present State of Women's Informatization Education

Korean Women's Development Institute (http://kwdi.re.kr/)
·Government investing research institute ·Constructs public database first in Korea in 1995. ·Systematizes the professional information related to women and provide it by PC communication network ·Construct total distribution management system on woman information and Internet service in 1997
FemiNet Korea (http://www.feminet.or.kr)
·Established in 1996 with the purpose of ' Woman Informatization '. ·Study on woman informatization, education, information culture business, operation of web-site ·Campaign on home informatization
Women Link (http://www.womenlink.or.kr)
·As professional woman movement organization, promote woman informatization ·Explore business to urge woman participation ·Plan the construction of DB on woman information
Asian Pacific Women's Information Network Center, Sookmyung Women's University (http://apwin.sookmyung.ac.kr/)
· Explore woman informatization project most actively among woman organizations attached to universities ·Construct Web-site in 1997 and provides information related to woman ·Hold international seminars · Obtain professionalism by connecting with other inside institutions attached to university including cyber institute ·Obtained the position of Chair of UNESCO · Play a role as main organization in woman informatization in Asia-Pacific regions including Korea and Japan.

<Table 1> Web site of representative women institutes

First, in the case of education, several women's organizations and social education centers for women hold basic computer training and some job training programs and lectures to expand the mind-set for informatization. However, the lectures are sporadic and temporary, and job training programs are limited to extremely small areas, and the content of training focuses on PC utilization, since it doesn't have the fundamental environment necessary.

Among informatization education at government levels, the women's professional training project of the Ministry of Information and Communication has been most systematically promoted. To solve the manpower problems and to nurture women professionals in the multi-media and content fields, the Ministry of Information and Communication has carried out various supporting projects since 1998. The main projects are shown below:

2.1.1 Support Educational Institute Attached to Women's Universities

This project is to support educational institutes attached to Women's Universities with educational expenses. Women university students and unemployed women will be intensively trained in the fields of information communication including S/W programming, system engineering, networking, and game · animation · media in prestigious education institutions exclusively for women, to get a job or open their own business.

2.1.2 Support 'The House of Working Women'

It also supports the education expenses of the House of Working Women. Homemakers and ordinary women can take training courses in the field of information and communication to get a job in the House of Working Women which has its own childcare center.

2.1.3 Support the Foundation of the Business Incubation Center of Women's Universities

To solve unemployment and to activate the foundation of businesses by women professionals, it supports the establishment of the Business Incubation Center in women's universities. With this project, about 16,000 students and homemakers have obtained information training in 1998, and about 250 woman professionals have established their own businesses.

2.1.4 Present State of Information Service and DB Building on Woman Informatization

Centered on a few women organizations and women research centers attached to universities including the Korean Women's Development Institute, FemiNet Korea, Asia-Pacific Women's Information Network Center, Sookmyung Women's University, women-related DB building and information services have been actively promoted. All these institutes have created the environment for women informatization based on the construction of N/W as an information infrastructure, and launched related education, culture and promotional projects.

In detail, 9 women's organizations out of 117, and 5 women's research centers out of 12 attached to universities that can operate social education programs besides the Korean Women's Development Institute, have operating Web Sites. Following are 4 organizations whose activities are the most active.

2.2 Problems in Woman Informatization Education in Korea

In Korea, accessibility to information devices is extremely different between genders. This difference of opportunity results in that of informatization and further causes severe inequality between genders as it becomes an informatization society.

A survey on Internet users by a Korean newspaper showed that the ratio of males to females among Internet users has largely changed. While the ratio of males to females from 1st to 3rd survey was 9:1, the 4th survey showed that female users had largely decreased the ratio discrepancy to 8.15: 1.85. Compared with the gender ratio among world Internet users (6.64 :3.36), that of Korea is found out to have a severe imbalance as ever[4].

Following is the concrete explanation of the problems of woman informatization in Korea[2].

First, the index of woman informatization is relatively low. Especially, that of homemakers was very low. Considering that the household is the basic unit of the nation, and responsible for enforcing social values through the supervision of the homemaker, it is a very severe problem.

Second, the number of women in higher professional training programs is decreasing, even though information training for woman at the regular or temporary training institutes is increasing quantitatively. As well, the professional training courses by temporary training institutes focus on the simple practice-oriented short-term training, reenacting the isolation phenomenon of women labor.

Third, in spite of the quantitative increase in informatization training for women, the number of women working in the information industry is being reduced. Information communication requires professional training in most fields, and it is necessary to make working environments in which women can continue to work and get in-service training even after getting married and having children.

3 Development Direction of Woman Informatization Education

With the advent of the informatization society, job areas divided by gender lost meaning, and accordingly women manpower can contribute to the development of society more and more. Unless fixed ideas on gender roles are discarded and replaced with a flexible way of thinking, the information estrangement of woman will become larger, and result in the loss of one axis of social development[6].
We will explore the development direction of informatization training of woman in the 21st century from this aspect.

3.1 Primary and Middle School Education

We would like to present the desirable direction of informatization education for girl students as follows:
First, school education should implement systematic education of information and provide as many opportunities as possible to allow girl students access to informatization education. Schools should also guide interest and instill a sense of closeness in information technology fields through the information technology related future course guidance after graduation.

In addition, the curriculum should be reorganized to make the most of information devices in each subject. Especially, careful attention should be given to organizing the education courses, so as not to isolate girl students, including elective courses only for girl students. Going one step further, information technology should be actively utilized in girls' elective courses including housekeeping and home economics courses, which will result in natural information education.

Second, the interest of girl students should be attracted to information through various activities including information contests for girl students. Excellent students should be picked out early and guided. Before determining whether the low index of woman informatization is inborn or learned, it is judicious for the government to give the highest consideration to the informatization of girl students in the education system.
Third, information education should be presented to the parents of those girl students who guide them at home. After all, home is the starting point and the last stop of education. An Information-oriented mind-set for students can be decisively affected by their parents. Especially, the informatization education of the parents of primary students has a high possibility to produce positives effect for the students. Accordingly, it will have a profound meaning in terms of education to provide informatization education which parents and students can participate in together.

Fourth, industrial-educational cooperation should be constructed for the education of girl students. Informatization education requires high-priced equipment and high quality personnel due to its character. It is difficult to say that hardware and software infrastructure for informatization education has been established in Korea. However, universities and industries have both foundation facilities and human resources, and as a result, the personnel trained at universities can be regarded as the consumer and beneficiary. Accordingly, the industrial-educational cooperation will result in an effective system for improving the quality of the informatization education and those institutes.

3.2 Policy Direction for Woman Informatization Education

We would like to present the desirable policy direction for the informatization education of women.

First, it is necessary to carry out education of women's problem at an early stage. Informatization education of women is to overcome the imbalance and irrationality that has emerged from gender discrimination. Accordingly, early education of women's problems should be carried out to enable them to overcome the sense of gender discrimination from the juvenile period, and help them with fundamental problem-solving.

Second, it is necessary to select the institutions or women organizations that can act as an axis of informatization education for women, and to allow them to play pivotal roles in that education. At present, many women's organizations have actively carried out and yielded some fruit. However, in reality, there is no center of woman informatization education that can collect the capabilities of many women's organizations. Informatization centers should be selected, networks by region and by institution should be created, and systematic and reasonable informatization education of women should be carried out. This network should also be expanded as an international organization through the Internet.

Third, it is necessary to rearrange and complement the education courses to connect school education to life-time education. For this purpose, education courses for the informatization education of girl students should be rearranged, which should result in systematic and hierarchical life-time education.

4 Conclusions

Due to the special nature of the information industry, women's labor power of processing and creation of knowledge has retained a new evaluation. Women's delicate nature, intellectual power, and creativeness herald the creation of new value. The emergence of new jobs and concepts of working places opens the new horizon for the possibility of the woman labor force. What is important here is, however, not to be satisfied with this possibility, but to turn this possibility into reality.

Educational fever in Korea is relatively high. The rate of women who go to universities is very high. Compared with those of advanced countries, however, less women with high education have made their way into the society, and as a result, the education for women remains as the consumptive type of education.

It is time to discard the view that the informatization education of women is just one area of expansion of

women's right. Korea has to recognize the importance of utilizing the tremendous number of potential women laborers as real available manpower, and to put a large investment and sufficient support into this.

References

[1] Asia-Pacific Women's Information Network Center, Sookmyung Women's University, http://apwin.sookmyung.ac.kr (accessed on July 30, 2000).
[2] Bong Suk, Son, "Information society and solidarity of women in Asia – Present status and assignments of woman informatization", FemiNet Korea(1998).
[3] FemiNet, Korea, http://www.feminet.or.kr/(accessed on July 30, 2000).
[4] Hankyoreh Newspaper, http://www.hani.co.kr/(accessed on July 30, 2000).
[5] Korean Women's Development Institute, http://kwdi.re.kr/(accessed on July 30, 2000).
[6] Tae Hee, Whang. "Women newspaper", Women newspaper office(1998).
[7] Women Link, http://www.womenlink.or.kr(accessed on July 30, 2000).
[8] Woman Newspaper, http://www.womennews.co.kr/(accessed on July 30, 2000).
[9] Young Whan, Yu, "Exploration on means to improve girl students' informatization ability. – Present status and development direction of woman informatization in Korea –", Korean Women's Development Institute(1998).

Reflections on Educational Technology from Female Asian Faculty's (FAF) Perspectives

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Four panelists in this panel session will briefly present their perspectives on how the instructional technology field has influenced current Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Presenters will address their challenges as female Asian faculty in Faculty development, Corporate training, In-Service teacher education, and Pre-service teacher education. Suggestions and solutions will be discussed during the panel session.

Keywords: **Faculty development, Corporate training, In-Service teacher education, Pre-service teacher education, reflection, and perspectives**

Introduction

Each panelist will offer their unique perspectives in the field of instructional technology. Our focus questions are:

1) Has instructional technology field influenced current:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S. C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

2) What are the challenges do female minority faculty encounter in:
* Faculty development (Dr. Mei-Yau Shih)
* Corporate training (Dr. Doris Lee)
* In-Service teacher education (Dr. Amy S.C. Leh)
* Pre-service teacher education (Dr. Mei-Yan Lu)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on In-service teacher education (Dr. Amy S.C. Leh)

Technology advancement is altering our society and our education. New technology standards grant opportunities, and policy reflect the change currently happening in our education. In September of 1997, the National Council for Accreditation of Teacher Education (NCATE) released a report addressing the importance of integrating technology into instruction. New technology standards clearly indicate that teachers must be competent of using technology in their teaching. Moreover, the Department of Education (DOE) has spent millions of dollars on grants to support teachers' training. The grants have brought many

university faculty members, school district administrators, and school teachers together to work on the task –technology integration. In the annual conference of Association for the Advancement of Computing in Education (AACE) 2000, Tom Carrell, director of PT3 grants addressed the influence of technology on our education and the need for organizational change. Some schools, for example, decided to only hire teachers who are competent of the use of technology.

At present, training teachers the use of technology has become a strong nation-wide movement and in-service teachers are expected to become technology literate through in-service training. The strong demand of teachers' training has invited many international scholars to participate in the movement of training US teachers the use of technology. The international scholars were mostly born outside of the United States, came to the USA for their higher education, e.g. Ph.D. degree, and are currently university faculty members at US universities.

The international faculty' participation brought new blood and tremendous strength into US in-service teacher education due to their educational experiences in both the USA and their native countries. Their experience with both educational systems allows them to compare how students learn in two different nations and to employ the strengths of each nation in the USA. For example, how an Asian student learns math is different from how a student in the USA. Asian students' math practice involves word problems (concepts) while the USA students' practice focuses on page after page calculation. An Asian Mathematics faculty, who was differently trained, might use a variety of effective teaching strategies due to the exposure to different ways of learning. Similarly, international Instructional Technology faculty may provide different perspectives in in-service teachers training. Because they are foreigners in the USA, they encounter challenges, especially international female faculty. Reports show that the percentage of female faculty in higher education is low. Some reports even indicate that they encounter more challenges than male faculty, e.g. in promotion. In this case, international female faculty would be minority within a minority and consequently encounter greater challenges. Below are examples of challenges:

"I felt that my viewpoints were not valued." (from an international male faculty)

"I felt that I was transparent in many meetings. They didn't seem to see my presence." (from an international female faculty)

"She [an international female faculty] couldn't get tenured because she was a foreigner." (from a US female faculty)

"You [an international female faculty] are double minority. You're female and foreign..You need to be firm and stand up for yourself." (from a US female faculty)

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Corporate Teaching (Dr. Doris Lee)

Today, employees in the corporate settings operate in a rapidly changing, high tech environment. Each employee, in order to accommodate the increasingly rapid rate of technology change, must continually re-tool and upgrade his or her skill sets through life-long learning. The delivery medium for life-long learning, most likely, will use instructional technologies. Instructional technologies refers to computer technologies that can integrate texts, graphics, audio, video, animation, or film clips for the creation of instructional or training packages. Recently, instructional technology also includes the use of the World Wide Web, WWW, in which instruction can be delivered over public or private computer networks and can be displayed by a web browser. Dr. Doris Lee, one of the panelists has taught corporate trainers for more than 10 years in the areas of instructional technologies and design and development of computer-based and web-based training. Based on such an experience, Dr. Lee's discussion in this panel will focus on the impact that the instructional technologies have on corporate training, and what are the challenges and perspectives that she faces as a female instructor for corporate trainers. Below details her experiences and views on these topics.

Generally, most corporations believe that the use of instructional technologies would provide an additional tool to the face-to-face training, can be designed to integrate multiple options including video, audio, and text to accommodate employees' preferred learning styles, and is valuable in providing consistent and current training to employees. In addition, the use of instructional technologies to deliver training can be time and place independent and therefore, costs associated with employees' travel and classroom training can be reduced. However, some companies express concerns in using instructional technologies. These concerns include employees' lack of computer and/or Internet skills, the design and development issues, and the software and hardware limitations.

To convince my students, who are corporate trainers, to consider all the important organizational factors and design issues while using instructional technologies is the biggest challenge. Most of the corporate trainers are female and work in a male-dominate environment. It is imperative for a female faculty to emphasize the importance of front-end analysis even if the analysis is not desirable by their male supervisors. When a company is considering using instructional technologies, a female trainer should never feel intimated to ask important questions including human, machine and political readiness. Questions such as, are the employees comfortable with computers and are they ready to learn, need to be asked. Next, technology readiness is another factor. Hardware, software, and the availability of a technical support staff are some examples of the areas that need to be evaluated. Also, financial readiness pertains to budgeting for upgrades to hardware and software, the purchase of courseware, and developing staff. Plus, political readiness concerns the support of instructional technologies by upper management, middle management, employees, and the training department. Finally, skill readiness looks at whether the staff involved with supporting and developing the training has the skills necessary to do so.

Reflection on educational technology from female Asian faculty' s (FAF) perspectives on Pre-service Education (Dr. Mei-Yan Lu)

Educational technology has played a major role in influencing pre-service education. For example, In the 60s, 70s, it was the audio-visual education. In the 80s it was computer assisted instruction (CAI), BASIC programming and Logo programming. In the 90s, it was multimedia, web-based learning.

As a female Asian faculty who has taught in major teacher training Institutes, I would like to share some of the unique challenges for preparing future teachers (per-service teachers) the past 16 years.

Challenge no. 1: Most pre-service teachers are young female white adults. Many of them do not have experiences in working with Asian faculty. For example, a typical K-12 school in San Jose, California, has mainly white teachers/administrators, in many cases, 100% white teachers/administrators while many of their students are from a diverse cultural background. Sometimes, a school student body is from 72 different language and cultural background.

Challenge no. 2: Most teacher preparation institute has mainly white faculty. For example, in the College of Education at San Jose State University which graduate, on the average, 600 credential teachers annually, has about 110 full time faculty. Out of the 110 full time faculty, only 6 are Asian faculty (Chinese, Japanese, and Korean).

Challenge no. 3: Most Asian female faculty are "foreign born'. The fact that we are different can offer unique perspectives to our students and colleagues. However, sometimes, our background and cultural differences can be barriers as well. For example, the accent issue. Some students and faculty complain that Asian faculty have heavy accent. However, they rarely complain the European Born faculty who has heavy European accent. Many times, they found European accent charming, while Asian accent distracting.

Challenge no. 4: The field of educational technology generally does not pay attention to solutions and strategies in designing instruction for audience from diverse cultural background. For example, in 1999 AECT convention, there were only two presentations in the entire conference program addressed the issue of designing for international and diverse cultural audience. As one of the popular instructional media – World Wide Web and distance learning is gaining more attention, we as instructional designers/faculty should pay more attention to the international audience.

My goal is to prepare technologically competent teacher candidates that are also culturally sensitive to work with diverse student population. With this goal in mind, I like to recommend:

1. Increase the representation of diverse student body in the field of educational technology both within the United States and outside of the United States.
2. Recruit more faculty of color. Therefore, students will have opportunity to work with both faculty and students from different cultural background.
3. Look beyond the "accent" issue. The point that I am trying to make is that more of the main stream Americans have no trouble "comprehend" accented English. They just do not like the way it "sound". In addition, people who speak with an accent are capable of speaking more than one language and be able to function effectively in another culture. Why not take their unique experience and learn how to design instruction for an international audience?

4. Encourage more educational technologists to research the cultural issues in designing instruction such as in the area of World Wide Web and distance learning.

Reflections on Educational Technology from Female Asian Faculty's (FAF) perspectives on Faculty Development (Dr. Mei-Yau Shih)

The use of instructional media in the classroom has long been identified as a "fourth revolution" in education (Ashby, 1967). It has the potential to reshape the role of the instructor from a knowledge conveyer to a guide and coach, while students take a more active role in the learning process. No longer are the textbook and instructor the sources of all knowledge; instead, the faculty member becomes the director of the knowledge-access process (Heinich 1996 et al,). Instructional technology refers not only the actual use of technological tools it also stresses the importance of the process of developing overall goals and strategies for enhancing teaching and learning. At its best, technology-based learning can help teachers support a wider range of learning styles, facilitate active learning in the classroom, use faculty time and expertise more effectively, and familiarize students with technology that will be vital for their futures in the world of work.
In our experience, university faculty are both greatly excited and daunted by the promise and power of teaching technologies. Our students have grown up in a "high technology" environment and are well adept at the use of TV, videotape, computers, and the Internet as information exchange tools. Many faculty, on the other hand, struggle to learn new technologies and to see how they might be useful to them as teachers (Shih & Sorcinelli, 2000). . The higher education is encountering the new trends of the changing student body, teaching practices, and the new roles and identities of faculty in universities. It is imperative, therefore, to remains a holistic view while helping faculty develop their technological skills with an understanding of the educational values and systems where the teaching and learning take places.

The perspectives from a foreign born female faculty developer, whose first 20 years of educational training differs massively from the majority of US university faculty on educational technology, reflect not only a personal challenge, they also underscore the important tasks of any faculty develop who serves as the chang agent in helping the transformation of teaching practice with instructional technology. These tasks include, first, effectively represent the instructional technology to faculty to help them see the integration of technology involves more than physical setup and technical support; it requires some curricular modifications and instructional strategy shifts; second, take in the cultural and educational differences in educational systems to design the strategies in energizing faculty and inspiring them trying innovative ways of teaching, and made them conscious about their purposes in the classroom; third, establish credibility and earn trust of the faculty to represent effectively the benefits of using technologies for teaching and learning; forth, remain alert and sensitive to the campus culture to help enhance the collegiality on campus, and maintain a supporting network of "exemplars" who would be eager to take risks and become "mentors" to colleagues who express interest in instructional technologies. Of most importance task as an Asian, female developer working for rising faculty technological skills is to help faculty recognize the diversity in college classroom, to make them conscious of the various student learning styles, ages, genders, race and ethnicity, and digital have' s and have-not' s issues in classroom. Effectively carry out these tasks is the means to the ends to help best researchers use and understand the instructional technologies to become a better and effective teacher in the 21st century.

REFERENCES

[1] Ashby, E., (1967). "Machines, Understanding, and Learning Reflections on Technology in Education." The Graduate Joumal, 7, pp. 359-373.

[2] Heinich, R., Molenda, M., Russell, J. & Smaldino, S. (1996). Instructional Media and Technologies For Learning. 5th Edition. Englewood Cliffs, New Jersey. Prentice-Hall, Inc.

[3] Shih, M. Sorcinelli, M.D.. (2000). "TEACHnology: Linking Teaching and Technology in Faculty Development." To Improve the Academy. V(18). POD Network. Anker Publishing Company, Inc. Bolton, Massachusetts.

Space Plan for Effective Educational Software Utilization in Korea

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Need of the ICT(Information & Communication Technology) based education has been emphasized and importance of educational software is being recognized, but it is not being utilized effectively. To solve this problem, we surveyed present conditions, recognition, and obstructive factors of educational software utilization for teachers of elementary schools, junior high schools, and high schools, and school inspectors who use educational software in their schools by questionnaire and interview. On the basis of the surveyed matters, we suggested a plan to utilize educational software effectively in the teacher, educational software, support system, and environment side.

Keywords: **Educational Software, Effective Utilization**

1 Introduction

1.1 Purpose

The key target of the educational informationalization business in Korea is to improve methods and quality of teaching and learning by using various educational software. For this, total 3,400 educational software have been developed and distributed in Korea from 1985 to 1998, and software purchase expenses of 1 million won per school have been supported from 1998 to use software developed by private hands.

Although lots of software are being distributed to each school like this, rate of teachers who have used educational software is lower than expected and schools continuously appeal lack of educational software. But definite and objective factors of why educational software is not used properly have not been found.

Therefore, a realistic and practical plan for effective educational software utilization should be prepared for teachers in their schools by finding problems and actual conditions based on development, distribution, and utilization of present software and gathering opinions of demanders and suppliers of educational software.

1.2 Content and Methodology

This study surveyed the followings by questionnaire and interview[1].

First, Present conditions of educational software utilization. Second, Recognition of educational software utilization. Third, Obstructive factors to educational software utilization.

The subjects of questionnaire were 1568 teachers of 128 schools(8 schools of each two elementary school, junior high school, academic high school, and vocational high school under the Education Administrations of national 16 cities/provinces were selected). Especially, for the above Third matter, interview was added for school inspectors in charge of educational informationalization, chiefs of the information department and teachers in charge of the task in the 9 Education Administrations.

2 Concept and Category of Educational Software

The educational software may be wholly utilized in the education and educational support field.

Jeong Taek-hee et al. define educational software as 'data or program that are directly inputted to a teaching-learning course and mediate interaction between teachers and learners to achieve the educational object'[2].

This study focused on data or educational software made for teaching-learning and set the concept of educational software as "software with teaching-learning purposes of a diskette, CD-ROM, and web type, containing educational matters made with each kind of authoring tools or programming languages". Also, presentation and digital encyclopedia type, which are being used a lot in the field, are included in it.

3 Analysis of Educational Software Utilization

The questionnaires were recalled from 84 schools among 128 schools which received them and the recall rate was about 65.6%. But among them, 6 schools respond unfaithfully, so questionnaires for just 78 schools were handled, the response rate was about 56.7% consequently.

3.1 Present Conditions of Educational Software Utilization

As a result of questionnaire, it was surveyed that 67.8% of respondents have used educational software during the class. But it is just 1 time use and most teachers responded that they did not utilize it now.

Enough	Over 70%	Over 50%	Under 50%	Under 30%	Almost not utilizing	No response	Total
34(4.6)	32(4.3)	66(9.0)	0(0)	65(8.8)	471(63.9)	69(9.4)	737(100)

<Table 3-1> Degree of educational software utilization

The results of surveying reasons for not utilizing(for intending not to utilize) educational software are as <Table 3-2>.

Place	Reason for not utilizing
1	There is no proper educational software.
2	It is not suitable for curricular characteristics.
3	It is thought that there is no special need.

<Table 3-2> Reasons for not utilizing educational software

3.2 Will of Utilization of Educational Software

It was found that respondents who responded that they had a plan to utilize educational software were far more than respondents who had responded that the had not to the question, "Will you use educational software in future?". So it shows that the will of teachers to utilize educational software was significantly high.

Yes	No	No response	Total
453(61.5)	61(8.3)	223(30.2)	737(100)

<Table 3-3> Will you utilize educational software in future?

The reasons for having a plan for software utilization are first, increase of educational efficiency, and second, improvement of teaching quality, and other responses were attraction of students' interests, improvement of a visual effect, and playing a role of a teaching helper.

3.3 Obstructive Factors to Educational Software Utilization

The fact that there is a will to utilize educational software but it is not utilized involves many suggestions. This study considered it as an obstructive factor to educational software utilization and surveyed it by interview. The reason for using interview instead of questionnaire was for consideration of the field conditions which cannot be expected by questioners.

3.3.1 Hardware

(1) Inadequacy of Hardware Environment: To utilize educational software, specifications of hardware should be good. A student has a computer as the level of a computer per 15.8 students including from 286 grade to pentium grade and as the level of a computer per 19.1 students in case of efficient over pentium grade for utilization in Korea. This can be sufficient basis to raise consistent voice for field teachers, 'hardware environment is inferior'.
(2) Inferior Maintenance System: Computer produces various maintenance conditions such as from software error to exchange of computer mainframe. But present condition is that teachers are not sufficient to decide correctly and cope with these conditions.

3.3.2 Educational Software

(1) Lack of Utilization Capability of Educational Software in a Class: There were many opinions that they fall in utilization as an intention of educational software developer is not the same as the intention of teacher in a class. And, it was appeared that it is difficult for the software to connect with curriculum as reconstructing of educational software is difficult.
(2) Lacked Information about Educational Software: When teacher wishes to utilize educational software in a class, information to guide him are so insufficient. This functions as a factor to refuse the utilization of educational software by teacher as well as work excess of teacher.

3.3.3 Teacher

(1) Lack of Utilization Ability and Absence of Practical In-service Training: To utilize educational software effectively, teacher must have the ability to connect the contents of educational software with instruction contents. In-service training can be an appropriate method to improve this ability. But In-service training executed now includes mainly learning of fundamental ICT or development of educational software rather than utilization of educational software.
(2) Lack of a Study Time of Teaching Materials: To apply the educational software on a class in the school field, teacher must confirm the hardware environment, understand the contents and type of educational software by checking, and has an ability to reconstruct the contents of class. He must check various things himself as there are no sufficient existing information for utilization and there is nearly no place to ask. However, it was appeared that teacher did not utilize educational software as his task is so much for these works.

4 Utilization Plan of Educational Software

We examined recognition of teachers, actual condition of utilization, and obstructive factor about educational software as mentioned above. In this study, we will prepare a plan to settle obstructive factors educational software effectively and practically on the basis of this.

4.1 Hardware

We will suggest the plan for hardware as the consideration of 2 conditions such as exchange of the existing old computer and new installation. And other various conditions must be considered for current educational software. In consideration of these condition, gradual plans of the following 3 steps are necessary.
First, basic utilization must be induced by distributing multimedia PCs in classroom primarily. Second, multimedia room must be installed by each school with the first step together. It is because that multimedia room can be utilized for storage of educational software, role of file server, and development of educational software. Third, installed hardware is required to maintain certainly and to reinstall. To ensure the continuous maintenance and reinstallment for hardware can give sense of stability to the school and extend efficient utilization of educational software.

4.2 Educational Software

To utilize educational software efficiently, most of all, educational software with good quality must be developed and distributed in the school field. In addition to the development of educational software with good quality, P.R. about developed educational software is necessary urgently. We suggest plans in

consideration of these conditions as follows.

First, DB on the development educational software must be provided by the level of Ministry of Education. DB must arrange and construct contents to be a standard of selection such as subject, type, and characteristics about each educational software when teachers wish to utilize educational software. Second, educational software must be manufactured with easy type for utilization in a class and its development breaks from the form of collection. And it must be manufactured as a form with easy change of structure according to the class intention of teacher. Third, educational software must receive financial support to evaluate the quality of educational software, which is developed by a private enterprise, and to purchase and use it if it is excellent educational software.

4.3 Teacher

First, in-service training about practice of educational software must be performed. In U.S., State of California performs a in-service training to raise practicable ability educationally in the second step, the level of teaching, of teacher training course[3]. In Korea, the school field also indicates problems of the existing training and requires the training of this level. To supplement problems of the existing training and change it for practical training, first, what part is considered to be the most difficult for teachers must be examined when they intended to use the educational software. And we must analyze hardware problems and software problems met in running educational software and must perform a training about countermeasures against these error conditions to teachers. Especially, we must improve the ability of educational software selection as we let them evaluate educational software and let them apply it on a class during in-service training course.

Second, we must give study time of teaching materials to teacher for utilizing educational software as aiming at efficiency of work by arranging school management and administrative structure. And on the basis of studied contents, we must make a mood to study teaching materials for teacher by giving advantages such as allowance and promotion marks to teacher who carries out developmental class.

4.4 School Support System

In our country now, policies applied on education are made by policy investigators after examination of various facts and then are instructed collectively. To be sure, they provide results of study to the other school by study exemplary school, but practical results of study are not gained due to the lack of source of revenues and manpower. It is also applied in suggesting efficient settlement plan about educational software. To settle these problems, the study composed by following 4 steps must be performed continuously.

First, investigate facts indicated as problems in the school field concentratedly. Second, understand practical problems by analyzing investigated contents. Third, prepare settlement plans for practical problems. Fourth, apply this on the system.

4.5 Reorganization of Curriculum

Great vast digitalized data are being produced due to the development of ICT and the acquisition is possible easily. If students want and try, they can utilize base environment, which has already been prepared, to be able to acquire great information than teachers. Under these environments, it is required to learn method and experience to produce valuable information by utilizing knowledge than committing to memory of knowledge simply. This shows that it is required to reconsider what we teach in the school field. But as current curriculum is knowledge-centered curriculum and ICT is accessed with only simple support level for progress of class, difficulties of teachers have been added a load. Therefore, to aim at efficiency of practical education, curriculum must be reorganized for integrating ICT into education. This means that ICT must not play only a supporting role of education but be a base of education[4].

5 Conclusion

As modern society became informationalization society and knowledge based society, the amount of information increases rapidly and its life is short. Students must live in these society conditions and school must grow society adaptability of students. Currently computer is discussed on the same level of reading,

writing, speaking. In these flow, the importance of educational software has increased. Utilization of educational software enables not only to progress efficient class but also to extend ICT applicable ability of students. But the utilization of educational software is greatly lower than necessity of educational software. To settle this problem, it is required of curriculum and teaching method met with information society and ICT must be not supporting means of education but a base of education. And, first of all, an important thing is field teachers. Systematic support is required to utilize educational software for field teachers and effort of teacher itself is required.

References

[1] Lee Tae-wuk., "Study about Efficiency Plan of Development · Distribution · Utilization of educational software", Education policy study. Ministry of Education(1999).

[2] Jung Taek-hee et al., "Study about quality management plan of educational software", Study report RR 90-18. Seoul: Korean Educational Development Institute(1990).

[3] Technology-Based Performance Standards For Educators, http://ctap.k12.ca.us/grants/teachstds.html (accessed on August 14, 2000).

[4] Davjd F. Salisbury, "Toward a New Generation of Schools:The Florida Schoolyear2000 Initiative", Educational Technology. July. P. 7, (1992).

The web of the Teacher Professional Development

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1 Introduction

The education reform is one of the main issues in Taiwan. It provides an opportunity for the universities to open a teacher education program. In teacher education program, it emphasis on pre-servise, internship, and in-servise teacher training. Therefore, the lifelong learning and teacher professional development become very important for teachers. In, addition, the Department of education in Taiwan listed the lifelong learning as one of the main objectives since 1986. The government also declared the year of 1997 as the lifelong learning year (Yang, 1996). Hence, the result of this study, the TPD web site, is to enrich the lifelong learning environment for teachers to improve their professional knowledge.

Today is an age of information. The computer and Internet are changing our daily life. These new communication technologies will replace the traditional communication technologies (Hsu & Hsu, 1998). The traditional computer education emphasized the tutoring function. Although the CAI provides the learner control and independent study, it is lack of the opportunity to the students to explore their learning and to experience the discovering the results. On the other hand, the Internet connects all computers and all the information to be a big information sharing system. Moreover, people who are using Internet in education can learn the lesson in anytime at anyplace with any kind of computer system. The Internet changes the learning style from the physical, aerial, closed system into a virtual, long-distant, and opened learning environment. The resoult of this study is a teacher professional development website system. There is information for the pre-education students, for the interns, and for the in-servise teachers.

One of he main characters in the information society is changing quickly. Teachers are asked to improve their teaching knowledge and skills while they are studying in the teacher education program, or practicing their teaching skill in the internship training, or attending workshop in their daily teaching job. The process of the teacher professional development begins from the pre-servise education, and then into the internship education, and finally the education for the in-servise teachers(chang & Hsu, 1996). In the pre-servise education, students start to study a set of the education professional knowledge, and start to form their attitute, education vision, and education commitment in order to develop the special characters of the educator for these students (Jaoun, 1984). The teacher education program contains the teaching theory-based courses, the teaching method-based courses, and the teaching internship-based courses (Yang, 2000). During the teaching internship program, the students learn with the in-servise teacher and the professor. The students get into the school system to learn all kinds of the knowledge and skills in school based environment (chen, 1995). For the in-servise teachers, though, they are accumilating lots of teachiing experence, they need to reflash their teaching knowledge and skills (Lee, 1996). Therefore, for those in-servise teacher with different kinds of teaching needs, the education program should consider the teachers needs and encourage them to work togather to help each other in order to meet their teaching needs (Moursuond, Bielefeldt & Underwood, 1997). Hence, this study is based on the theory of the teacher professional development to development a virtural communication environment for teachers in order to achieve the goal of the teacher professional development.

The TPD web site will provide the information for all kinds of teachers. There are two purposes of this study. One of the puropose of this study is to enrich the literature of the teacher professional development. The other purpose of this paper is to build up a network-learning environment for those who are in pre-teacher program, internship, and on job training to improve their professional ability.

2 Conclusions

The result of this study is to build up a teacher professional development web site(http://www.tep.tku.edu.tw/3ic). It contains pre-servise education program courses, the information for the internship teachers, and the lifelong infromatioin for the in-servise teachers. There is a virtural classroom to provide the teaching manegement function to teachers. In addition, it contains the communiction function to various of teachers by using disscussion groups or BBS. The function of the questionnare is to provide a tool for action research. When teachers use this function to create the questionnare and send it by e-mail or web, the system will collect and analysis the data.

This study is based on the theory of the teacher professional development to develop a web site. The result of this study is not only to build up a teacher professional development web site but also to enrich the literature of the co-operative learning model. By developing this virtural lifelong learning web system, the future studies on the co-operation between different kinds of teachers are needed.

3 References

Hsu, F. C. & Hsu, C. L.(1998). The behavior for Media choice in Taiwan. Proceeding of the International Information Management Conferrence. pp.469-479.

Chang, Y. F. & Hsu, C. L.(1998). System Development for Teacher Professional Development, *Instructional technology & media*, No. 40, pp.3-11

Yan, K. S.(1998). Lifelong Education Policy and Strategy in Taiwan. Paper present at Educational Technology and Lifelong Learning.

Joan, C. W.(1996). Teacher Professional Development –Theory and Practice. Taipei. Wu-nan.

Chen, M. Y.(1997). Teacher Profession-Teaching Concept and Practice. Kaochun. Li-wen

Moursund, D., Bielefeldt, T., & Underwood, S. (1997). Computer Technology and Professional Development: Suggestions for schools. Http://www.iste.org/Resources/Projects/RoadAhead/Pd.html

Using Learning Object Meta-data in a Database of Primary and Secondary School Resources

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The Learning Object Meta-data (LOM) is an emerging standard for annotation of educational entities (digital or nondigital) that are relevant to technology-supported learning. The annotations describe educational, legal, and technical characteristics of these resources. The IEEE Learning Technology Standards Committee sponsors development of this standard. In this paper we describe an application of the LOM to the construction of a database of resources available to schools in Hawai'i, and report on both successes and issues encountered. Recommendations are made concerning modifications to the LOM and adoption of the LOM by others working in primary and secondary school contexts.

Keywords: **Standards, Meta-data, Resource Databases**

1 Introduction

Internet technology for learning, including web-based resources, networked groupware and remote sensing have the potential to bring teachers and students together with a greater diversity and quantity of human, natural and technological resources than was previously possible. Educators and students can now access an enormous variety of web-based expository materials, images, activity plans, simulations, etc., and interact with people from many walks of life over the Internet. Already pressed for time, how will educators sort through this cornucopia of information and misinformation and find the resources appropriate for the educational needs of their students? Clearly, in order to leverage the great potential of this de-facto worldwide digital library, educators will need help. This paper is concerned with one form of help: databases of *meta-data* or information that describes the relevant characteristics of educational resources sometimes called *learning objects*. Properly constructed meta-data databases that have interfaces designed to match educator's perspectives should enable them to find relevant learning objects more quickly.

There are two other factors that also motivate this work. In the United States, there is currently a strong emphasis on systemic reform in public school education at the primary and secondary school levels. Being *systemic*, this movement is encouraging and compelling a greater diversity of stakeholders to collaborate in their mutual interest in supporting achievement of high standards in the schools. For example, the Educational System Reform (http://www.ehr.nsf.gov/EHR/ESR/) division of the US National Science Foundation requires that proposals for funding show evidence of significant collaborations between schools, universities and colleges, business and industry, and other community members in genuine support of sustainable reform (i.e., reform that continues beyond the funded period). As a result, organizations and individuals who have not previously worked together need to become aware of the resources they offer to each other. Hence databases of resources that are tailored for particular locations are needed. The present work is one example of such a database.

A third motivating factor is economic. The cost of building educational materials, particularly technology-supported materials such as software, is high. All too often, persons and groups who are intellectually prepared to develop innovative new approaches to the application of technology to education spend most of their time rebuilding basic functionality. Recent interest in educational object repositories and educational

technology standards is motivated in large part by the desire to be able to find and reuse the work of others. Standards are being developed to describe learning objects [5] and to facilitate the interoperability of these objects once they are found [3]. This work is concerned primarily with standards for describing learning objects so that they may be found. Software interoperability has been addressed elsewhere (e.g., [2, 6]). Standards for describing learning objects also address economic issues surrounding resource databases because databases are expensive to build. Rather than replicate existing meta-data, it is preferable to access existing meta-data repositories. However, this requires standard forms for meta-data.

In summary, these forces require educators and their partners to be aware of the diversity of resources that are potentially available to them and to understand the significance or potential utility of these resources with respect to educational objectives. Resource databases should adequately describe a diverse variety of resources yet relate them all to common educational objectives, describe the resources in terms understandable to educators, and interoperate with other major repositories. In this paper we report on our first efforts to design such a resource database to meet these needs within the State of Hawai'i as part of a systemic initiative known as Hawai'i Networked Learning Communities. Specifically we report on our use of an emerging standard, the Learning Object Meta-data (LOM). The paper provides a brief introduction to the LOM, describes its application to HNLC, and discusses limitations and extensions to the LOM that were required. Finally, readers are provided with information on how to participate in the development of the LOM.

2 Background

2.1 Learning Object Meta-data

Meta-data, simply defined, is data about data [4, 7]. Meta-data defines the characteristics of other data so that it may be interpreted and used intelligently. In this sense meta-data enables us to use data as *information*. The phrase *learning object* is used to inclusively denote a wide variety of entities used to support learning, including but not limited to digital resources such as software, multimedia, or hypertext, and nondigital resources such as courses of study, professional development programs, or persons who have volunteered to serve as mentors. Assembling these concepts, we come to *learning object meta-data*, which is somewhat of a misnomer in that the meta-data is not only describing data, but also other entities that are not data (such as persons). Yet the term "meta-data" is already in wide use for this purpose, so will be used herein.

2.2 Technical Standards

A *technical standard* is a specification of shared terms, interfaces, representations, practices, etc. If an artifact (such as computer or networking hardware, a software program, or data representations) is constructed to be compliant with a technical standard, then that standard ensures that multiple stakeholders will be able to interpret or interface with that artifact without needing to ask for help from the creator of the artifact. That is, a standard helps ensure interoperability and reuse. A standard is expressed in a document that sets forth the scope and purpose of the standard and the mandatory conditions for compliance. The existence of a standard, e.g., for learning technologies, does not mean that everyone is expected to comply with the standard. It only sets forth the conditions for those who elect to claim compliance with the standard.

2.3 The IEEE LTSC Learning Object Meta-data

The IEEE (Institute of Electrical and Electronics Engineers, http://www.ieee.org/) is an international organization for engineers of electrical and information technologies. IEEE has a well-defined standards development process administered by its Standards Activity Board (http://www.computer.org/standards/). The Learning Technology Standards Committee (LTSC), which was founded in 1996 by a group of academic, government, and industry representatives (including the author), chose to use the IEEE standards process for this reason. The LTSC sponsors several learning technology related standards efforts, at various levels of maturity ranging from speculative to approaching balloting. The Learning Object Meta-data draft standard [1] (also known by its IEEE identifier as 1484.12) is arguably the most mature of the LTSC draft standards. According to a recently circulated revision to the Project Authorization Request, "The purpose of this standard is to facilitate search, evaluation, acquisition, and use of learning objects, for instance by learners or instructors. The purpose is also to facilitate the sharing and exchange of learning objects, by enabling the development of catalogs and inventories, taking into account the diversity of cultural and lingual contexts in which the learning objects and their meta-data will be exploited."

The LOM standard is meant to provide a semantic model for describing properties of the learning objects themselves, rather than detailing ways in which these learning objects may be used to support learning. The LOM indicates the legal values and informal semantics of the meta-data elements, their dependencies on each other, and how they are composed into a larger structure. It is intended to be extended, and in fact a structure has been provided specifically for the purpose. The LOM is agnostic concerning *bindings* or implementations of meta-data in particular representations or notations, such as XML. (At this writing, a study group is exploring a separate XML binding specification.) No particular representation or implementation is specified or implied by the LOM. Systems that are LOM compliant may present users with any interface they wish and store the meta-data however they wish. The LOM specifies only the semantics of the meta-data in order to enable meaningful interchange of meta-data between systems.

An outline of the LOM meta-data elements as of draft 4.1 [1] is provided in Table 1. In this table, nesting indicates a compositional relationship. For example (adopting notation commonly used in the LOM committee), a single 1.3:Catalog.Entry consists of a 1.3.1:Catalogue and an 1.3.2:Entry; while a 9:Classification consists of several types of sub-elements, some of which themselves also have internal structure. Much important information has been left out of this table for space considerations. For example, some data elements may take on multiple values which may be ordered or unordered, and some must be taken from restricted vocabularies or reference other standards for their values.

Table 1 Outline of Learning Object Meta-data Elements

- **1 General**
  - 1.1 Identifier
  - 1.2 Title
  - 1.3 CatalogEntry
    - 1.3.1 Catalogue
    - 1.3.2 Entry
  - 1.4 Language
  - 1.5 Description
  - 1.6 Keywords
  - 1.7 Coverage
  - 1.8 Structure
  - 1.9 Aggregation Level
- **2 LifeCycle**
  - 2.1 Version
  - 2.2 Status
  - 2.3 Contribute
    - 2.3.1 Role
    - 2.3.2 Entity
    - 2.3.3 Date
- **3 MetaMeta-data**
  - 3.1 Identifier
  - 3.2 Catalog Entry
    - 3.2.1 Catalogue
    - 3.2.2 Entry
  - 3.3 Contribute
    - 3.3.1 Role
    - 3.3.2 Entity
    - 3.3.3 Date
  - 3.4 Meta-data Scheme
  - 3.5 Language
- **4 Technical**
  - 4.1 Format
  - 4.2 Size
  - 4.3 Location
  - 4.4 Requirements
    - 4.4.1 Type
    - 4.4.2 Name
    - 4.4.3 Minimum Version
    - 4.4.4 Maximum Version
  - 4.5 Installation Remarks
  - 4.6 Other Platform Requirements
  - 4.7 Duration
- **5 Educational**
  - 5.1 Interactivity Type
  - 5.2 Learning Resource Type
  - 5.3 Interactivity Level
  - 5.4 Semantic Density
  - 5.5 Intended end user role
  - 5.6 Context
  - 5.7 Typical Age Range
  - 5.8 Difficulty
  - 5.9 Typical Learning Time
  - 5.10Description
  - 5.11Language
- **6 Rights**
  - 6.1 Cost
  - 6.2 Copyright and Other Restrictions
  - 6.3 Description
- **7 Relation**
  - 7.1 Kind
  - 7.2 Resource
    - 7.2.1 Identifier
    - 7.2.2 Description
    - 7.2.3 CatalogEntry
- **8 Annotation**
  - 8.1 Person
  - 8.2 Date
  - 8.3 Description
- **9 Classification**
  - 9.1 Purpose
  - 9.2 TaxonPath
    - 9.2.1 Source
    - 9.2.2 Taxon
      - 9.2.2.1 Id
      - 9.2.2.2 Entry
  - 9.3 Description
  - 9.4 Keywords

Brief descriptions of the major element categories follow. *1:General* provides information such as title, a brief textual description, and keywords. *2:Life.Cycle* describes the development and current state of the resource. *3:Metameta.Data* describes the meta-data itself, e.g., who entered or validated this meta-data instance and what language it is written in. *4:Technical* provides information on media type, size, software requirements, etc. for those learning objects to which these attributes apply. *5:Educational* is intended to provide basic information about the pedagogical characteristics of the resource. This category includes some of the most controversial elements, to be discussed further below. *6:Rights* describes the conditions under which one may acquire and use the learning object. *7:Relation* is intended to describe the learning object in relation to other learning objects. At this writing there is a controversy concerning whether this may be used to control sequencing of a collection of learning objects, or whether that should be deferred to other standards being developed for the purpose. *8:Annotation* allows for the accumulation of comments by persons who have used or are otherwise evaluating the learning object. *9:Classification* provides a means of extending the LOM to meet specialized needs. 9:Classification comes in the form of a generic structure for classifying the learning object in one or more taxonomic systems external to the LOM. Most of our extensions used 9:Classification.

3 HNLC Resource Database

The remainder of this paper describes our first prototype design and implementation of a learning object resource database, specifically focusing on the use of the LOM as a guiding framework for the design, and on ways in which extensions to the LOM were required. I briefly describe the initiative that this database was intended to serve before discussing the application of the LOM itself.

3.1 Hawai'i Networked Learning Communities

The Hawai'i Networked Learning Communities (HNLC, http://lilt.ics.hawaii.edu/hnlc/) initiative is a partnership between the Hawai'i Department of Education (HDOE), the University of Hawai'i, and many other stakeholders in the quality of Hawai'i public education, such as business and nonprofit interests. HNLC's purpose is to prepare all students in Hawai'i's public schools for life and careers in today's world by enabling them to attain high standards in science, math, engineering and technology (SMET) education. The HNLC initiative is supporting HDOE in its systemic standards-based reform efforts by leveraging Hawai'i's rich land, sea, space, and cultural resources. A theme of "global environmental studies, situated locally" pervades the work. From the standpoint of technology-supported learning, HNLC has three major thrusts. First, professional development will help educators make better use of technologies as educational resources in their classrooms. Second, distance collaboration and remote sensing technology will bridge the distances between small rural schools and the islands' rich resources, enabling virtual access to field sites, research laboratories or equipment, and, most importantly, peers and mentors of students, teachers and others involved in the educational process. Third, a web-accessible database will address one of the most frequent requests encountered during our needs assessment: knowing what resources are available to educators in Hawai'i. This paper is about the suitability of the LOM for this database.

3.2 Scope of the Database

The database describes resources for public school education ranging from Kindergarten (K) to 12th grade, also abbreviated as K-12. Standards-based reform is essential to the initiative: hence all resources must be described with respect to the Hawai'i Content and Performance Standards (http://www.hcps.k12.hi.us/), a document specifying what should be taught and how students' learning should be assessed. A wide variety of resources will be described, making this a particularly challenging test implementation of the LOM. For example, the following resources might be included:

- A university program in which Ph.D. students have their expenses paid in exchange for mentoring teachers for a certain number of hours a month. This can take place over the Internet; ideally, the teacher's students become involved in field report in support of the Ph.D. thesis.
- Nationally recognized curricular resources developed at the University's Curriculum Research and Development Group (http://www.hawaii.edu/crdg/).
- A software program with which students can construct explicit visual models of their evidential reasoning while participating in investigations (http://lilt.ics.hawaii.edu/belvedere/index.html).
- A network of autonomous weather stations and remote controlled cameras, to be placed in the Alaka'i swamp (one of the rainiest place on Earth) or Volcano National Park, in some cases with the cameras

trained on individuals of endangered plant species, with radio links to the Internet (http://www.botany.hawaii.edu/pods/).

- A nurse practitioner at a local military hospital who volunteered her time to telementor students on medical topics.
- Malama Hawai'i, a new environmental education project started by the famed Polynesian voyager Nainoa Thompson (http://www.malamahawaii.org/).
- Advanced placement courses in computer science and discrete math, offered by our department to high school students via Hawai'i DOE's Internet-based E-School (http://atr.k12.hi.us/eschool/index.shtml).
- The He'eia Ahupua'a, in which researchers and school children collaborate to study the integration of modern and traditional Hawai'ian land management techniques (Internet collaboration and mentoring is being planned: http://kauila.k12.hi.us/~ahupuaa/).
- A Community College's research grade 24" telescopes, recently displaced from Haleakala by larger telescopes and now being installed for Web-accessible use at the CC. The telescopes are still viable for new asteroid, comet and supernova survey research that can be conducted by high school students over the web, being supervised by college students and their professional mentors.
- Diverse resources for teaching constructed by teachers and made available to others as part of a new product-oriented approach to professional development credits being implemented by HDOE.

All of these fall within LOM's scope of "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning" (from the original Project Authorization Request, http://ltsc.ieee.org/par-lo.htm) because we will be using distance collaboration and remote sensing technology (as well as the database itself) to support learning using these resources. To control the scope of our work, HNLC will prioritize the description of local resources and interface with other repositories for nationally available resources (e.g., GEM).

4 HNLC LOM Meta-data

In designing the meta-data for resources such as those listed above, we found it necessary to extend the LOM. As previously noted, the LOM was designed to be extended. In some cases the predefined LOM elements were adequate, and in other cases we were able to perform the desired extensions using the LOM 9:Classification facility. However in a few cases it was necessary to extend restricted vocabularies (which is not normally allowed), and in other cases structural issues arose. In this section I describe the most significant extensions, including the issues just mentioned.

4.1 Method

Our team consisted of Susan Johnson and Beth Tillinghast (Library and Information Science students), Laura Girardeau (an Environmental Education graduate), and David Nickles (a Computer Science graduate).

Initially Johnson and Tillinghast wrote informal textual descriptions capturing the important information about a representative sample of the resources that we wanted to describe. After reviewing these descriptions I presented the LOM draft 4.1 [1] to the entire team, which required extensive discussions for clarification. We then went through the textual descriptions and identified LOM elements in which the information expressed could be captured. Where we failed to find LOM elements for an item of information we extended the LOM, either by expanding on the vocabulary of an existing element or by creating an entirely new element under 9:Classification.Where new elements were needed we searched other repositories to find meta-data that we could use. Several iterations were required to understand the LOM structure well enough to define our instances of 9:Classification. (It should be noted that end users are not expected to understand the LOM: the LTSC community expects that suitable interfaces will be developed, and no end user will even need to know that the LOM exists. We were approaching the LOM as information professionals, not end users.) Then Nickles created a Filemaker implementation of the resulting HNLC-LOM and provided the others with an interface for building meta-data (Figure 1). Johnson and Tillinghast then created meta-data for our sample. I then reviewed the result to detect possible misunderstandings and issues. I also compiled a first draft of issues and recommendations. This draft was shared with the LTSC LOM committee, both via email and subsequently face to face in an LTSC meeting (Montreal, June 2000). Thanks to their feedback, many issues were resolved or re-understood as non-issues, and many further clarifications resulted.

4.2 Vocabularies

The data type of LOM elements may be primitive (e.g., a string), reference other standards (e.g., vCard), or consist of a controlled vocabulary. In the latter case, the vocabulary may be restricted, meaning that only the terms listed may be used, or open with recommended practice, meaning that one should attempt to use one of the terms listed as the recommended practice but may extend this vocabulary if needed. One extends the vocabulary by using a tuple of form (See_Classification, *term*). The *term* is the new term being added to the vocabulary. One must define an instance of 9:Classification that has the same 9.1:Purpose as the data element being extended, and define a 9.2:Taxon.Path as needed to indicate where the term falls within the taxonomic system indicated by 9.2.1:Source. (A taxon path can be thought of as a sequence of taxons, which begins at the root of a taxonomic hierarchy and works its way down the tree through intermediate nodes to the leaf node under which the object is being classified.)

For example, suppose one wants to extend 5.2:Learning.Resource.Type with the term "Curriculum" taken from the Gateway to Educational Materials (GEM) Resource Type vocabulary, (http://www.geminfo.org/Workbench/Metadata/Vocab_Type.html).
One would place the tuple (See_Classification, "Curriculum") in the 5.2 location, and then construct an instance of 9:Classification with 9.1:Purpose = Learning.Resource.Type, a single 9.2:Taxon.Path with 9.2.1:Source = "GEM Resource Type," and a single 9.2.2:Taxon with 9.2.2.2: Entry = "Curriculum" (there is no ID available).

Although this seems much more awkward than simply using the term "Curriculum" in the 5.2:Learning.Resource.Type field, two points should be kept in mind. First, it is a powerful general-purpose way of extending vocabularies with information about the taxonomic source of the term, and hence its semantics. If we were to simply add a termto 5.2:Learning.Resource.Type its semantics would be inaccessible, as there would be no place to record where the term came from. Second, the LOM information structures are neither specifications of an implementation nor specifications of a user interface: implementations are free to reorgainze the presentation of information to the user as convenient (e.g., to present extensions to vocabularies *as if* they were simply added to the same field in question).

We found several of the LOM vocabularies for 5:Educational to be insufficient for our purposes. In one case, 5.2:Learning Resource Type, the vocabulary was open and the insufficiencies could be addressed via the extension mechanism just described. However, vocabularies for 5.1:Interactivity.Type (values: Active, Expositive. Mixed, or Undefined) and 5.5:Intended.End.User.Role (Teacher, Author, Learner, Manager) are restricted vocabularies, so cannot be extended in this way. We have made the recommendation that these be changed to open vocabularies until better consensus on an adequate term set can be obtained with the help of the various communities expected to be using the LOM.

4.3 Structural Issues

In some cases we felt that the vocabulary should be replaced with a structured description. This was actually the case for 5.1:Interactivity.Type and 5.5:Intended.End.User.Role (see next section), as well as 5.7:Typical.Age.Range. Concerning the latter, K-12 educational resources in the United States are almost always referenced by grade level rather than age range. Other applications may require other measures Anticipating the need for flexibility, we recommended that 5.7:Typical.Age.Range be changed to a structured element with 5.7.1 Measure (e.g., "Chronological Age," "GEM Grade," etc.) and 5.7.2:Value (e.g., "12," "7-8," etc.).

More problematic are ways in which the value of one element depends on another. We noted that 5.9:Typical.Learning.Time depends on 5.7:Typical.Age.Range, for example, a textbook might be described as suitable for a fast paced graduate course or a two-semester undergraduate sequence. Erik Duval later pointed out that this applies to 5.4:Semantic.Density and 5.8:Difficulty as well. Hence I recommended reorganizing these elements in a manner such as the following:

5.x Challenge Level, consisting of one or more 4-tuples:
- 5.x.1 Educational Level (formerly 5.7), consisting of one or more pairs:
  - 5.x.1.1 Measure (e.g., Age, US Grade, …)
  - 5.x.1.2 Value (e.g., 7-8)
- 5.x.2 Semantic Density (formerly 5.4)
- 5.x.3 Difficulty (formerly 5.8)
- 5.x.4 Learning Time (formerly 5.9)

Then one could create multiple instances of 5.x: Challenge.Level, with the values of 5.x.2 through 5.x.4 being dependent on the value of 5.x.1:Educational.Level. It is possible to *implicitly* achieve the same effect by replicating entire LOM metadata instances, one for each developmental level (or age); but we feel that it would be far more perspicuous and efficient to acknowledge the dependency explicitly in a structure such as the above.

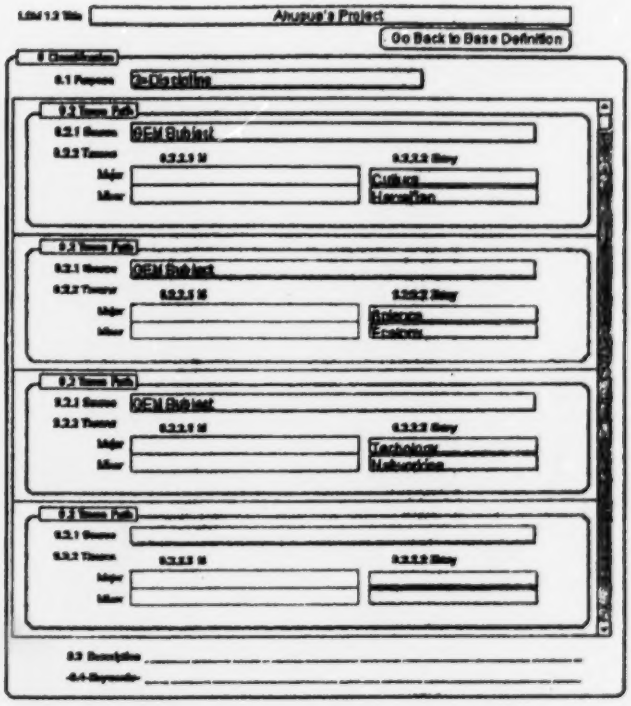

Figure 1. Prototype HNLC Resource Database: a Discipline classification

4.4 Our Extensions to the LOM

The following extensions were made using 9:Classification.

4.4.1 Audience

This extension effectively replaces 5.5:Intended.End.User.Role with the GEM Audience (http://www.geminfo.org/Workbench/Metadata/Vocab_Audience.html), a two-part classification consisting of ToolFor (who uses the tool) and Beneficiary (who benefits). For example, a professional development resource that helps teachers handle learning disabled children in their classes is for the teacher but benefits the particular population of learning disabled students. We would prefer that 5.5: Intended.User.Role be modified to be composed of 5.5.1:Tool.For and 5.5.2:Beneficiary.

4.4.2 Community Involvement

This extension describes how a resource interacts with various stakeholders. We are designing this classification ourselves. We are considering a two-part classification: One for the community entity involved, and the other for the type of involvement.

4.4.3 Discipline

This extension describes the subject matter area covered by the resource. There is presently no LOM field that does this (other than possibly 1.7:Coverage, which has limitations beyond the scope of this paper). We are using the GEM Subject. This is a two-level classification system, requiring a two-step Taxon Path, for example Science/ Astronomy. We found it necessary to add two first-level classifications to the GEM Subject: Technology and Culture. An example using these subjects is shown in Figure 1, a partial screen dump of our Filemaker prototype implementation. We also needed a way to indicate cross-curricular integration. For this we again elected to modify the GEM taxonomy by allowing any major level Subject

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header to be listed as a minor header under the subject with which it is integrated. For example, Science/Mathematics would indicate that the resource integrates Mathematics into Science (since Mathematics is normally a Major taxon). For the GEM Subject controlled vocabulary see http://www.geminfo.org/Workbench/Metadata/Vocab_Subject.html.

4.4.4 Educational Level

This extension augments LOM 5.7:Typical.Age.Range, and is structured as described in the previous section.

4.4.5 Educational Objectives

This extension addresses content and performance standards. It is distinct from Discipline because it is more specific: it aligns the resource with the particular standards that the resource is intended to help achieve. Examples of national (US) content and performance Standards include America's Choice (http://www.ncee.org/ac/intro.html); NCTM standards for mathematics (National Council of Teachers of Mathematics, http://nctm.org/standards/); the NSES for science (National Science Education Standards, http://www.nap.edu/readingroom/books/nses/html/), and the National Educational Technology Standards (NETS http://cnets.iste.org/). An example of a state standard is the Hawai'i Content and Performance Standards (http://www.hcps.k12.hi.us/).

4.4.6 Pedagogy

This extension addresses the *severe* deficiency of the LOM's 5.1:Interactivity.Type, a closed vocabulary of {active, expositive, mixed, undefined}. We have recommended that the vocabulary for 5.1 be reopened. However our version provides an even richer description of interactivity, using the GEM Pedagogy controlled vocabulary. This vocabulary (http://www.geminfo.org/Workbench/Metadata/Vocab_Pedagogy.html) has three facets: Teaching Methods (GEM provides a large vocabulary), Grouping (individual, small group, large group, etc.), and Assessment (which is sometimes integrated into the pedagogy).

5 Conclusion

Internet technology for learning, including groupware and remote sensing, have the potential to bring teachers and students together with a greater diversity of human, natural and technological resources than was previously possible. Additionally, the current emphasis on systemic reform in public school education in the United States is encouraging and compelling a greater diversity of stakeholders to collaborate in their mutual interest in supporting achievement of high standards in the schools. These forces require that educators and their partners be aware of the resources that are potentially available to them and to understand the significance or potential utility of these resources with respect to educational objectives. The HNLC Resource Database is being designed to meet such a need in the context of systemic standards-based reform in the state of Hawai'i. The demands on such a database are high: it should interoperate with other major repositories, adequately describe a diversity of resources, yet relate them all to common content and performance standards and generally describe the resources in terms understandable to educators. The LTSC's Learning Object Meta-data (LOM) is being developed in part to lay the foundations for meeting such needs. In this paper I described our attempt to use the LOM for the HNLC Resource Database. We found that it provides a solid foundation in the form of many well thought out data elements as well as a means for extension. We also found that the LOM does not address all the needs of the HNLC Resource Database. This cannot be expected as the LOM is being designed to serve a variety of applications in government and industry as well as public education. We were able to deal with most of the limitations through the Classification method of extension. However some of these extensions were due to premature closure of the LOM vocabularies. More problematic were structural dependencies between LOM elements that are not well captured at present. These issues were illustrated with examples from K-12 education.

The Learning Object Meta-data standard is under active development at this writing. It is hoped that this paper will help increase awareness within the primary/secondary education sector worldwide of the LOM standards effort, and encourage your contribution to further development of the standard to be more appropriate for primary/secondary education needs. Anyone may participate: see http://ltsc.ieee.org/ for details.

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References

1. IEEE Std. 1484.12 (draft). Draft 4.1 of the Learning Objects Metadata (LOM), IEEE, Piscataway, N.J., USA, 2001. Available: http://ltsc.ieee.org/doc/wg12/LOM_WD4.htm
2. Koedinger, K., Suthers, D., and Forbus, K. (1999). Component-based Construction of a Science Learning Space. International Journal of Artificial Intelligence in Education (1999), 10, 292-313. (Also available at http://cbl.leeds.ac.uk/ijaied/home.html)
3. Miller, P. (2000). Interoperability: What is it and why should I want it?. Ariadne 24. Available: http://www.ariadne.ac.uk/issue24/interoperability/
4. Milstead, J. & Feldman, S. (1999a). Metadata: Cataloging by any other name. Online 23(1), 24-31. Available: http://www.onlineinc.com/onlinemag/OL1999/milstead1.html
5. Milstead, J. & Feldman, S. (1999b).Metadata: Projects & standards. Online 23(1), 32-40. Available: http://www.onlineinc.com/onlinemag/OL1999/milstead1.html#projects
6. Roschelle, J., DiGiano, C., Koutlis, M., Repenning, A., Phillips, J., Jackiw, N.,& Suthers, D. (1999). Developing educational software components. Computer, 32(9), pp. 50-58. Piscataway, NJ: IEEE Computer Society.
7. Wason, T. D. (unpublished). Dr. Tom's Meta-Data Primer. Available: http://www.imsproject.org/drtommeta.html